Dell™ PowerVault™ MD3000i RAID Enclosure

Hardware Owner's Manual

Notes, Notices, and Cautions

NOTE: A NOTE indicates important information that helps you make better use of your computer.

NOTICE: A NOTICE indicates either potential damage to hardware or loss of data and tells you how to avoid the problem.

CAUTION: A CAUTION indicates a potential for property damage, personal injury, or death.

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Model AMP01

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1

About Your System

The Dell™ PowerVault™ MD3000i is a 3U rack-mounted external Redundant Array of Independent Disks (RAID) storage array capable of accommodating up to 15 3.0-Gbps, Serial-Attached SCSI (SAS) disks. The RAID enclosure can be daisy-chained with up to two additional MD1000 expansion enclosures, providing access to a maximum of 45 disks in the entire storage array. Connectivity between the RAID enclosure and the host server is provided by a standard Ethernet connection, and communication between the two is established through an iSCSI initiator.

Overview

The RAID enclosure is designed for high availability, offering redundant access to data storage. It features support for both single RAID controller configuration and dual RAID controller configuration. For each configuration, up to 16 hosts can be connected through industry-standard 1-Gb network interface cards (NICs).

The MD3000i storage array provides dual active/active RAID controller modules, redundant power supplies, and redundant fans. The RAID enclosure is designed for high-performance environments: eight-node clusters or multi-host storage access for up to 16 host servers.

Storage management can be either in-band through the iSCSI connection, or out-of-band using an Ethernet connection to the Management Port on the RAID controller modules.

Enclosure Features

Features include:

- Support for up to 16 Microsoft Windows® or Linux host servers
- 3U chassis for rack mounting
- RAID controller modules in two supported configurations:
  - Single-controller configurations
  - Dual-controller configurations for high availability

- Two redundant, hot-pluggable power supply/fan modules
- 512 MB of mirrored cache on each RAID controller module
- Battery backup unit in each RAID controller module that protects against cache data loss for up to 72 hours
- Support for up to 45 3.5" SAS physical disks
- Support for up to 255 virtual disks per disk group
- Up to 2 TB (2036 GB) storage on a single virtual disk
- Support for up to two PowerVault MD1000 expansion enclosures through SAS Out port connectors on the RAID controller modules
- Online firmware updates (without taking the enclosure offline) for the following components:
  - RAID controller modules
  - NVSRAM
  - Physical disk

    NOTE: Dell recommends stopping all I/O to the array when downloading physical disk firmware.

  - Expansion enclosure management modules (EMMs)
- Task-based configuration software (MD Storage Manager)
- Optional snapshot virtual disk (premium feature), up to four snapshots per virtual disk and 128 snapshots per array
- Optional virtual disk copy (premium feature), up to 255 virtual disk copies per array
- Continuous background event monitoring for critical problems, such as impending physical disk failure or failed RAID controller modules
- Host-based, multipath failover software for redundant configurations to automatically reroute I/O activity from a failed, offline, or removed RAID controller module to its alternate RAID controller module (or from a failed iSCSI connection). This capability maintains a data path between the host server and the storage array.

Modular Disk Storage Manager

The Modular Disk (MD) Storage Manager software is a graphic interface with wizard-guided tools and a task-based management structure designed to reduce the complexity of installation, configuration, management, and diagnostic tasks. MD Storage Manager can be used on any host server attached to the storage array, as well as on storage management stations connected to the same subnetwork as the RAID enclosure, to create and manage multiple storage arrays.

NOTE: The MD Storage Manager uses TCP/UDP port 2463 for discovery and management of the MD3000i storage array.

For more information, see the *MD Storage Manager User's Guide*.

Other Information You May Need

CAUTION: The *Product Information Guide* provides important safety and regulatory information. Warranty information may be included within this document or as a separate document.

- The *Rack Installation Guide* or *Rack Installation Instructions* included with your rack solution describes how to install your enclosure into a rack.
- *Getting Started With Your System* provides an overview of enclosure features, setting up your enclosure, and technical specifications.
- *Setting Up Your PowerVault MD3000i* provides an overview of setting up and cabling your storage array.
- The *PowerVault MD3000i Installation Guide* provides installation and configuration instructions for both software and hardware.
- The *PowerVault MD Storage Manager CLI Guide* provides information about using the command line interface (CLI).
- The Dell PowerVault MD3000i *Resource CD* provides documentation for configuration and management tools, as well as the full documentation set.
- Dell PowerVault MD1000 Documentation is available at **support.dell.com** for users who incorporate MD1000 expansion enclosures.
- Dell PowerEdge Cluster Documentation is available at **support.dell.com**. A link to clustering documentation is also included on the *Resource CD* under **Product Documentation**.

- Updates are sometimes included to describe changes to the enclosure, software, and/or documentation.

  NOTE: Always check for updates on **support.dell.com** and read the updates first because they often supersede information in other documents.

- Release notes or readme files are included to provide last-minute updates to the enclosure or documentation or advanced technical reference material intended for experienced users or technicians.

Connection Components

Before connecting your RAID enclosure, ensure that the following are available:

- The components that shipped with your RAID enclosure, including:
  - Power cords (2)
  - *MD3000i Resource CD*
  - *Setting Up Your PowerVault MD3000i*
  - Rail kit
- Any relevant documentation, including:
  - *Getting Started With Your System*
  - *Rack Installation Guide* or *Rack Installation Instructions*
  - *Product Information Guide* (for important safety, regulatory, and warranty information)
  - Readme files
- #2 Phillips screwdriver

About the Enclosure Connections

The RAID enclosure is connected to a host server via two RAID controller modules. The RAID controller modules are identified as RAID controller module 0 and RAID controller module 1 (see Figure 1-4).

Each RAID controller module has two iSCSI In port connectors that provide connection to the host server. The iSCSI In port connectors are labeled **0** and **1**.

Each MD3000i RAID controller module also contains a SAS Out port connector. This port allows you the option to connect the RAID enclosure to an expansion enclosure.

Refer to the *PowerVault MD3000i Installation Guide* for details and illustrated examples of how to configure your storage array.

Hardware Features

The remainder of this section describes the hardware features available on the RAID enclosure, including:

- Indicators on the enclosure bezel
- Front-panel and back-panel indicators and features
- Redundant power supply and cooling fan modules

Indicators on the Enclosure Bezel

An optional locking bezel can be installed on the front of the enclosure to limit access. Figure 1-1 illustrates the indicators and components on the bezel. Table 1-1 lists conditions indicated by the lights on the bezel. For information on installing and removing the bezel, see "Removing and Replacing the Front Bezel" on page 55.

Figure 1-1. LEDs on the Front Bezel

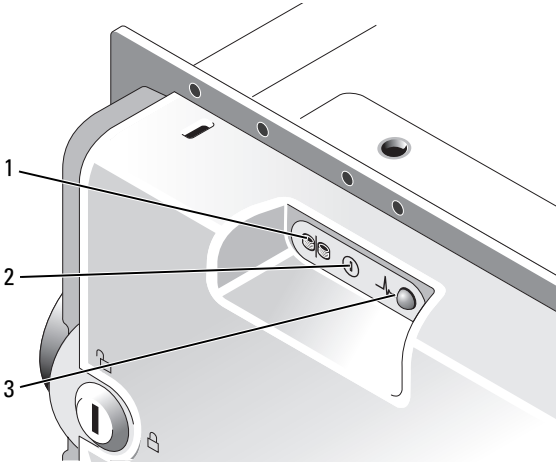


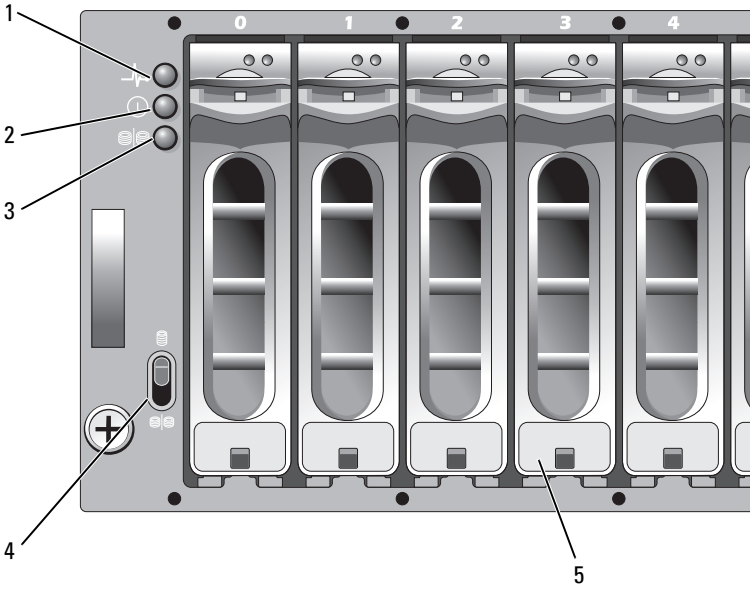
Table 1-1. Front-Bezel Indicators

Item	LED Indicator	LED Icon	Condition
1	Split mode (green)		Because this mode is unused in the system, this LED should always be unlit. **NOTE:** This LED comes on if the enclosure mode switch on the enclosure's front panel is in the split mode position before the enclosure is turned on.
2	Power (green)		When lit, at least one power supply is supplying power to the enclosure.
3	Enclosure status (blue/amber)		**Steady amber:** Power is on and enclosure is in reset state. **Steady blue:** Power is on and enclosure status is OK. **Flashing blue:** Enclosure LED is being blinked by MD Storage Manager. **Flashing amber:** Enclosure is in fault state.

Front-Panel Indicators and Features

Figure 1-2 shows the LED indicators and components on the enclosure's front panel (optional locking bezel not shown). Table 1-2 lists the conditions and functions indicated by each.

Figure 1-2. Front-Panel Features



1	enclosure status LED	2	power LED	3	split mode LED (not used)
4	enclosure mode switch	5	physical disks (15)		

Table 1-2. Front-Panel Components

Component	Icon	Condition
Enclosure status LED (blue/amber)		Steady amber: Power is on and enclosure is in reset state. Steady blue: Power is on and enclosure status is OK. Flashing blue: Enclosure LED is being blinked by MD Storage Manager. Flashing amber: Enclosure is in fault state.

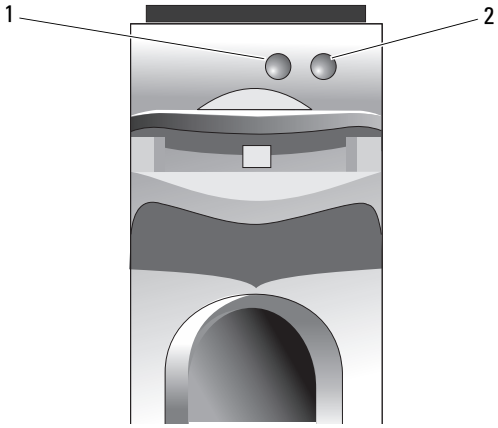
Table 1-2. Front-Panel Components *(continued)*

Component	Icon	Condition
Power LED (green)		When lit, at least one power supply is supplying power to the enclosure.
Split mode LED (green)		Because this mode is unused in the system, this LED should always be unlit. **NOTE:** This LED comes on if the enclosure mode switch on the enclosure's front panel is in the split mode position before the enclosure is turned on.
Enclosure mode switch		The function of this switch is not applicable to your MD3000i. However, if additional MD1000 expansion enclosures are daisy chained to your system, the enclosure mode switch on those enclosures must be in unified-mode position. **NOTE:** This switch must be set prior to turning on the system. Changing the switch setting after the system is turned on will have no effect on enclosure configuration until the system goes through a complete power cycle.

Physical Disk Carrier LED Indicators

Each physical disk carrier in your enclosure has two LEDs: an activity LED (green) and a bicolor (green/amber) status LED (see Figure 1-3). The activity LED flashes whenever the physical disk is accessed. Table 1-3 lists the flash patterns for the status LED.

Figure 1-3. Physical Disk Carrier LED Indicators



1 activity LED 2 status LED

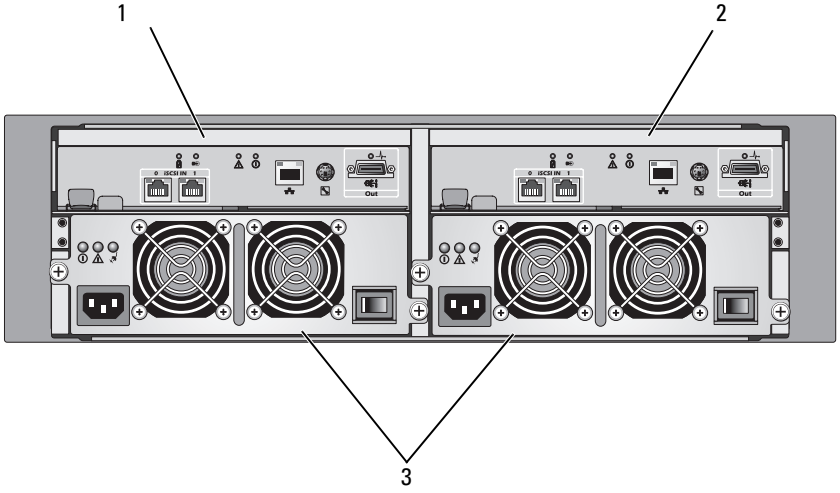
Table 1-3. Physical Disk Carrier Status LEDs

Status LED	Description
Off	Physical disk not yet discovered by host server or an unsupported disk is present
Steady green	Physical disk is online
Green flashing (250 milliseconds [ms])	Physical disk is being identified
Green flashing On 400 ms Off 100 ms	Physical disk rebuilding
Amber flashing (125 ms)	Physical disk failed
Flashing green, amber, and off	Physical disk failure predicted (SMART)
Green 3 seconds, amber 3 seconds, and off 3 seconds	Physical disk rebuild aborted

Back-Panel Indicators and Features

Figure 1-4 shows the back-panel features of the enclosure. A fully populated enclosure with dual RAID controllers and two power supply/cooling fan modules is shown. However, a single RAID controller module is supported, and the enclosure can run temporarily on one power supply/cooling fan module. For more information, see "Power Supply and Cooling Fan Features" on page 24.

Figure 1-4. Back-Panel Features



1	RAID controller module 0	2	RAID controller module 1	3	power supply/cooling fan modules (2)

RAID Controller Modules

The RAID controller modules provide high-performance, advanced virtual disk configuration, and fault-tolerant disk subsystem management. Each RAID controller module contains 512 MB of cache that is mirrored with the other controller's cache for high availability and protected by a battery for up to 72 hours.

Each RAID controller module provides data path and enclosure management functions for your enclosure, including:

- Monitoring and controlling enclosure environment elements (temperature, fans, power supplies, and enclosure LEDs)
- Controlling access to the physical disks
- Communicating enclosure attributes and states to the host server

Each RAID controller module has dual iSCSI In ports for host access. The two iSCSI ports provide redundant host connections and support a high availability storage environment. Various configurations can be utilized, in both single controller and dual controller mode, to connect the storage enclosure to hosts depending on specific redundancy needs. For example:

- **Single Path Data Configuration** – The single path provides a large number of nonredundant physical connections to the array through an industry-standard Gigabit Ethernet Switch.
- **Redundant Dual Path (RDP) Data Configuration** – The RDP allows two separate physical paths for each client through a Gigabit Ethernet Switch. In addition, this configuration provides full redundancy through the use of either redundant disk array controller (RDAC) drivers or multipathing I/O (MPIO) drivers.

For detailed information on cabling, see the *PowerVault MD3000i Installation Guide*.

RAID Controller Module Connectors and Features

Figure 1-5 shows a single RAID controller module as it appears from the rear of the enclosure. RAID controller module connectors and components shown include:

- Two iSCSI In port connectors
- Management port Ethernet connector

NOTE: The RAID controller module network configuration can be assigned using a DHCP server (the default setting). If a DHCP server is not available (time-out is 10 seconds) then the RAID controller modules uses the static IP addresses of 192.168.128.101 for controller 0 and 192.168.128.102 for controller 1.

- Eleven LEDs (two iSCSI In link speed/activity, two iSCSI In link duplex mode, two Ethernet link/speed, battery fault, SAS link fault/connectivity, cache active, controller fault, and controller power)
- One SAS Out port connector
- Debug port

For a description of each component on the front panel of the RAID controller module, see Table 1-4. For an explanation of how to connect the enclosure using the RAID controller module ports, see the *PowerVault MD3000i Installation Guide*.

Figure 1-5. RAID Controller Module External Panel (front view)

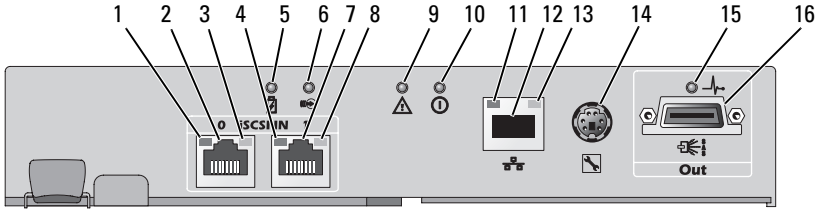


Table 1-4. RAID Controller Module Component Functions

Item	Component	Icon	Function
1	iSCSI In Port 0 Link Speed/Activity Status LED		Green: Link is operating at 1000 Mbps. Amber: Link is operating at 100 Mbps. Off: iSCSI connection is not active.
2	iSCSI In Port 0	In-0	Provide host-to-controller iSCSI connection. If LED is solid, there is no activity on the link. If the LED is blinking, there is activity on the link.
3	iSCSI In Port 0 Link Duplex Mode		Green: Full-duplex mode. Off: Half-duplex mode. **NOTE:** Half-duplex mode is supported only if the link speed is 100Mbps.

Table 1-4. RAID Controller Module Component Functions *(continued)*

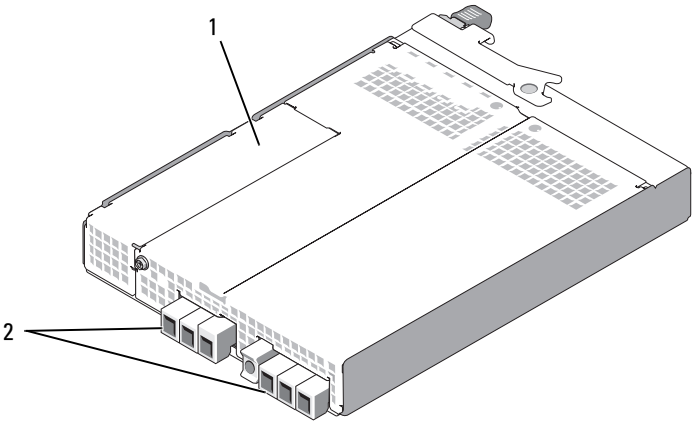
Item	Component	Icon	Function
4	iSCSI In Port 1 Link Speed/Activity Status LED		Green: Link is operating at 1000 Mbps. Amber: Link is operating at 100 Mbps. Off: iSCSI connection is not active.
5	Battery Fault LED (amber)		Amber: Battery backup unit or battery has failed or is missing. Off: Battery backup unit and battery is operating normally.
6	Cache Active LED (green)		Green: On-board controller memory contains data. Off: On-board controller memory is empty.
7	iSCSI In Port 1	In-1	Provide host-to-controller iSCSI connection. If LED is solid, there is no activity on the link. If the LED is blinking, there is activity on the link.
8	iSCSI In Port 1 Link Duplex Mode		Green: Full-duplex mode. Off: Half-duplex mode. **NOTE:** Half-duplex mode is supported only if the link speed is 100Mbps.
9	Controller Fault LED (amber)		Amber: Controller fault detected. Off: Controller is operating normally.
10	Controller Power LED (green)		Green: Controller power is on. Off: Controller is not powered.
11	Ethernet Link LED (green)		Green: Ethernet connection is active. Off: Ethernet connection is not active.
12	Management Port Ethernet Connector		Provide a 10/100 Mbps Ethernet connection for out-of-band management of the enclosure.

Table 1-4. RAID Controller Module Component Functions *(continued)*

Item	Component	Icon	Function
13	Ethernet Speed LED (green)		Green: Ethernet connection is operating at 100 Mbps. Off: Ethernet connection is operating at 10 Mbps or is not active.
14	Debug Port		Dell support only.
15	SAS Link Fault LED		Amber: Between 1–3 links are connected. Green: All four links are connected. Off: All links are down.
16	SAS Out Port	Out	Provides SAS connection for cabling to a downchain expansion enclosure.

The RAID controller module connects to the enclosure midplane via the two midplane connectors on its internal (rear) panel. The RAID controller module is shown in Figure 1-6.

Figure 1-6. RAID Controller Module



1 battery cover 2 midplane connectors (2)

Battery Backup Unit

Each RAID controller contains a three-cell lithium-ion battery backup unit (BBU) that powers the controller's cache memory and preserves the cache contents in the event of a power outage of up to 72 hours. The RAID controller firmware performs a test of the BBU at startup and will illuminate the battery fault LED if the battery is not operating within specified ranges, or if the battery is missing. The battery begins recharging automatically if the test determines that it is necessary. For a description of the battery fault LED, see Table 1-4. For information on removing and installing the BBU, see "Removing and Installing a RAID Controller Module Backup Battery Unit" on page 62.

NOTE: For virtual disks, the RAID controller firmware changes the data cache setting based on the state of the battery. If the battery is missing or does not have sufficient charge, the controller flushes the cache and sets the write cache attribute to Write Through for all virtual disks. When the battery is replaced, Write Back is reenabled.

The RAID controller module logs the age of the battery and issues a replacement reminder message approximately six weeks before expiration. After replacing the battery, you must use MD Storage Manager to reset the battery age.

RAID Enclosure Thermal Shutdown

Enclosure management provides a feature that automatically shuts down the enclosure when the temperature within the storage enclosure exceeds a safe threshold. Thermal shutdown protects the data on the physical disks from corruption in the event of cooling system failure. Because the battery backup unit protects against cache data loss for up to 72 hours, all data in the cache is saved. It is not necessary to shut down any expansion enclosures attached to the storage enclosure.

Temperature threshold values are used to determine the temperature at which shutdown occurs. These thresholds are default settings and cannot be changed. If the temperature sensors on the backplane detect a temperature exceeding the Nominal Failure Threshold, a critical event is set. If the Maximum Failure Threshold is reached, shutdown of the enclosure power supplies occurs within 3 minutes. A third threshold, the Shutdown Threshold, shuts down the enclosure power supplies within 5 seconds after it is reached.

Cache Functions and Features

Cache Mirroring

The cache mirroring function copies accepted host-write data from the primary controller to the partner controller. This action ensures that host-write data is safely mirrored to the partner controller before successful completion status is returned to the host. If a controller fails, the surviving controller safely retains all mirrored data. Cache mirroring is enabled by default.

Write-Back Cache

Write-back cache is a caching strategy whereby write operations result in a completion signal being sent to the host operating system as soon as the cache receives the data to be written. The target physical disk will receive the data at a more appropriate time in order to increase controller performance. In dual-active controller configurations with write-back caching enabled, the write data is always copied to the cache of the second controller before completion status is issued to the host initiator. Write Back is enabled by default.

Write-Through Cache

Write-through cache is a caching strategy whereby data is written to the physical disk before completion status is returned to the host operating system. Write-through cache is considered more secure than write-back cache, since a power failure is less likely to cause loss of data. The RAID controller automatically switches to write-through if cache mirroring is disabled or if the battery is missing or has a fault condition.

NOTE: Write cache settings are not user-configurable.

Power Supply and Cooling Fan Features

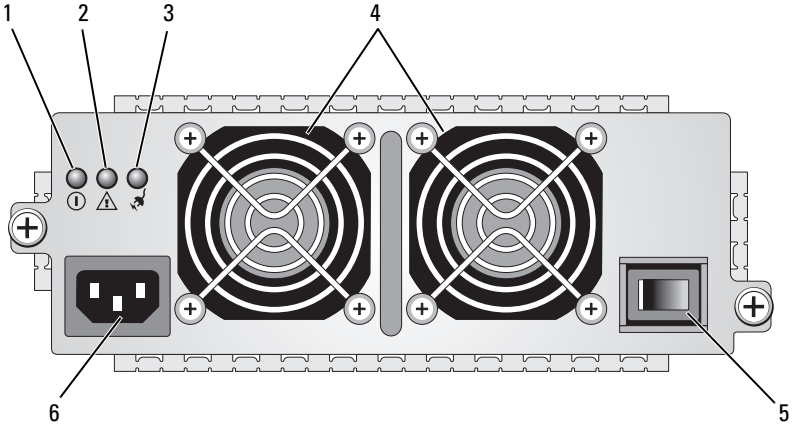
Your RAID enclosure supports two integrated, hot-pluggable power supply/cooling fan modules. Both modules must be installed to ensure proper cooling. Each module contains two separate cooling fans. The enclosure requires at least three of the cooling fans to operate to avoid overheating.

CAUTION: A power supply/cooling fan module can be removed from a powered-on enclosure for a maximum period of no more than 5 minutes. Beyond that time, the enclosure may automatically shut down to prevent damage to the enclosure and/or enclosure components.

A power supply/cooling fan module can be replaced without powering down the enclosure. For information on removing and replacing the modules, see "Removing and Installing the Power Supply/Cooling Fan Module" on page 64.

Figure 1-7 shows the power supply/cooling fan module features and LED indicators. Table 1-5 lists the LED indicator descriptions.

Figure 1-7. Power Supply and Cooling Fan Module LED Features and Indicators



1	DC power LED	2	Power supply/cooling fan fault LED	3	AC power LED
4	cooling fans (2)	5	on/off switch	6	AC power connector

Table 1-5. Power Supply/Cooling Fan Module LED Indicators

Type	Color	Icon	Function
DC power	Green		**On:** DC output voltages are within specifications. **Off:** No power or voltages not within specifications.
Power supply/cooling fan fault	Amber		**On:** DC output voltages are not within specifications or one (or both) fans are in fault. **Off:** No fault condition is present.
AC power	Green		**On:** AC input voltage is within specifications. **Off:** No power or voltages not within specifications.

2

Using Your RAID Enclosure

This section covers the following information:

- Basic concepts of a RAID solution including physical disks, virtual disks, and disk groups
- RAID levels supported by MD Storage Manager
- Hot spare operations and rebuilds
- Media errors and unreadable sectors
- RAID operations and features
- Advanced RAID features
- Hardware redundancy and failover including cabling
- Updating enclosure firmware
- Best practice recommendations

Physical Disks, Virtual Disks, and Disk Groups

Physical disks in your RAID array provide the physical storage capacity for your data. Before you can begin writing data to the storage array, you must configure the physical storage capacity into logical components, called *disk groups* and *virtual disks*.

A disk group is a set of physical disks upon which multiple virtual disks are created. The maximum number of physical disks supported in a disk group is 30. You create disk groups from unconfigured capacity on your storage array.

A virtual disk is a partition in a disk group that is made up of contiguous data segments of the physical disks in the disk group. A virtual disk consists of data segments from all physical disks in the disk group. Virtual disks and disk groups are set up according to how you plan to organize your data. For example, you might have one virtual disk for inventory, a second virtual disk for financial and tax information, and a third virtual disk for customer information.

All virtual disks in a disk group support the same RAID level. The RAID enclosure supports up to 256 virtual disks (minimum size of 10 MB each) that can be assigned to host servers. Each virtual disk is assigned a Logical Unit Number (LUN) that is recognized by the host operating system.

Physical Disks

Only Dell-supported 3.0-Gbps SAS physical disks are supported in the storage array. If the RAID controller module detects unsupported physical disks, it marks the disk as unsupported and the physical disk becomes unavailable for all operations.

NOTE: The MD3000i enclosure must contain at least two physical disks for proper operation. This is necessary because the physical disks are used to store configuration information.

Physical Disk States

The RAID controller module recognizes the physical disk states (*mode* and *status* reported in MD Storage Manager) described in Table 2-1.

Table 2-1. RAID Controller Physical Disk States

Status	Mode	Description	Physical Disk Status LED Indication
Optimal	Unassigned	The physical disk in the indicated slot is unused and available to be configured.	Steady Green
Optimal	Assigned	The physical disk in the indicated slot is configured as part of a disk group.	Steady Green
Optimal	Hot Spare Standby	The physical disk in the indicated slot is configured as a hot spare.	Steady Green
Optimal	Hot Spare In Use	The physical disk in the indicated slot is in use as a hot spare within a disk group.	Steady Green

Table 2-1. RAID Controller Physical Disk States *(continued)*

Status	Mode	Description	Physical Disk Status LED Indication
Failed	Assigned, Unassigned, Hot Spare In Use, or Hot Spare Standby	The physical disk in the indicated slot has been failed because of an unrecoverable error, an incorrect drive type or drive size, or by its operational state being set to failed.	Amber flashing (125 ms)
Replaced	Assigned	The physical disk in the indicated slot has been replaced and is ready to be, or is actively being, configured into a disk group.	Green flashing (On 400 ms, Off 100 ms)
Pending Failure	Assigned, Unassigned, Hot Spare In Use, or Hot Spare Standby	A SMART error has been detected on the physical disk in the indicated slot.	Flashing Green, Amber, and off
(none)	(none)	The indicated slot is empty, or the array cannot detect the physical disk.	Off

If a disk drive rebuild fails because of a source drive failure or because the drive is too small, the user interface reports a failure of the physical disk even though the LED state on the drive indicates the rebuild was aborted (green for 3 seconds, amber for 3 seconds, then off for 3 seconds).

Self-Monitoring Analysis and Reporting Technology (SMART)

Self-Monitoring Analysis and Reporting Technology (SMART) monitors the internal performance of all physical disk components to detect faults indicating the potential for physical disk failure. SMART uses this information to report whether failure is imminent so that a physical disk can be replaced before failure occurs. The RAID controller monitors all attached drives and notifies users when a predicted failure is reported by a physical disk.

Virtual Disks and Disk Groups

When configuring a storage array, you would normally proceed in this order:

- Organize the physical disks into disk groups.
- Create virtual disks within these disk groups.
- Determine which host servers you want to grant access to which virtual disks, then create mappings to associate the virtual disks with the host servers.

NOTE: Host server access must be created prior to mapping virtual disks to them.

Disk groups are always created in the unconfigured capacity of a storage array; virtual disks are created within the free capacity of a disk group. *Unconfigured* capacity is comprised of the available physical disk space that is not already assigned in the storage array. *Free* capacity is the space in a disk group that has not been assigned to a virtual disk.

Creating a Virtual Disk

To create a virtual disk, use one of the following methods:

- Create a new disk group from unconfigured capacity. You can define the RAID level and capacity (the number of physical disks) for the disk group, then define the parameters for the first virtual disk in the new disk group.
- Create a new virtual disk in the free capacity of an existing disk group. You only need to specify the parameters for the new virtual disk.

Virtual Disk States

The RAID controller module recognizes the following virtual disk states.

Table 2-2. RAID Controller Virtual Disk States

State	Description
Optimal	The virtual disk contains physical disks that are all online.
Degraded	The virtual disk with a redundant RAID level contains an inaccessible physical disk. The system can still work properly, but performance may be affected and additional disk failures may result in data loss.
Offline	A virtual disk with one or more member disks in an inaccessible (failed, missing, or offline) state. Data on the virtual disk is no longer accessible.

Supported RAID Levels

RAID levels determine the way in which data is written to physical disks. Different RAID levels provide different levels of accessibility, redundancy, and capacity.

Using multiple physical disks has several advantages over using a single physical disk, including:

- Placing data on multiple physical disks, called *striping*, means that input/output (I/O) operations can occur simultaneously and improve performance.
- Storing redundant data on multiple physical disks using *mirroring* or *parity* supports reconstruction of lost data if an error occurs, even if that error is the failure of a physical disk.

Each RAID level provides different performance and protection. You should select a RAID level based on the type of application, access, fault tolerance, and data you are storing.

The storage array supports RAID levels 0, 1, 5, and 10.

RAID 0

RAID 0 uses disk striping to provide high data throughput, especially for large files in an environment that requires no data redundancy. RAID 0 breaks the data down into segments and writes each segment to a separate physical disk. I/O performance is greatly improved by spreading the I/O load across many physical disks. Although it offers the best performance of any RAID level, RAID 0 lacks data redundancy (fault tolerance). Choose this option only for non-critical data, because failure of just one physical disk will result in the loss of all data.

RAID 1

RAID 1 uses disk mirroring so that data written to one physical disk is simultaneously written to another physical disk. This is recommended for small databases or other applications that do not require large capacity. RAID 1 provides full data redundancy, meaning that if one disk fails, the mirrored disk automatically maintains throughput with no data loss.

RAID 5

RAID 5 uses parity and striping data across all physical disks (distributed parity) to provide high data throughput and data redundancy, especially for small random access. RAID 5 is the most versatile RAID level and is suited for multi-user environments where typical I/O size is small and there is a high proportion of read activity.

RAID 10

RAID 10, a combination of RAID 1 and RAID 0, uses disk striping across mirrored disks. It provides high data throughput and complete data redundancy. Utilizing an even number of physical disks (four or more) creates a RAID level 10 disk group and/or virtual disk. Because RAID levels 1 and 10 use disk mirroring, half of the capacity of the physical disks is utilized for mirroring. This leaves the remaining half of the physical disk capacity for actual storage. RAID 10 is automatically used when a RAID level of 1 is chosen with four or more physical disks.

RAID Level Usage

To ensure best performance, you should select an optimal RAID level when you create a system physical disk. The optimal RAID level for your disk array depends on a number of factors, including:

- Number of physical disks in the disk array
- Capacity of the physical disks in the disk array
- Need for redundant access to the data (fault tolerance)
- Disk performance requirements

RAID 0 is best used for video editing, image editing, prepress applications, or any application requiring high bandwidth.

RAID 1 offers fast performance and the best data availability, but also the highest disk overhead. It is best used for accounting, payroll, or financial applications.

RAID 5 is best used for file, application, database, web, e-mail, news, and intranet servers.

RAID 10 works well for medium-sized databases or any environment that requires high performance and fault tolerance and moderate-to-medium capacity.

Segment Size

Disk striping enables data to be written across multiple physical disks. Disk striping enhances performance because striped disks are accessed simultaneously.

The segment size or stripe element size specifies the size of data in a stripe written to a single disk. The MD3000i supports stripe element sizes of 8, 16, 32, 64, 128, 256, and 512 KB. The default stripe element size is 128 KB.

Stripe width, or depth, refers to the number of disks involved in an array where striping is implemented. For example, a four-disk disk group with disk striping has a stripe width of four.

NOTE: Although disk striping delivers excellent performance, striping alone does not provide data redundancy.

Hot Spares and Rebuild

A valuable strategy to protect data is to assign available physical disks in the storage array as *hot spares*. A hot spare adds another level of fault tolerance to the storage array.

A hot spare is an idle, powered-on, stand-by physical disk ready for immediate use in case of disk failure. If a hot spare is defined in an enclosure in which a redundant virtual disk experiences a physical disk failure, a rebuild of the degraded virtual disk is automatically initiated by the RAID controller modules. If no hot spares are defined, the rebuild process will be initiated by the RAID controller modules when a replacement physical disk is inserted into the storage array.

Global Hot Spares

The MD3000i supports global hot spares. A global hot spare can replace a failed physical disk in any virtual disk with a redundant RAID level as long as the capacity of the hot spare is equal to or larger than the size of the configured capacity on the physical disk it replaces, including its metadata.

Hot Spare Operation

When a physical disk fails, the virtual disk automatically rebuilds using an available hot spare. When a replacement physical disk is installed, data from the hot spare is copied back to the replacement physical disk. This function is

called copy back. By default, the RAID controller module automatically configures the number and type of hot spares based on the number and capacity of physical disks in your system.

A hot spare may have the following states:

- A *standby hot spare* is a physical disk that has been assigned as a hot spare and is available to take over for any failed physical disk.
- An *in-use hot spare* is a physical disk that has been assigned as a hot spare and is currently replacing a failed physical disk.

Rebuild

If a disk fails in a fault-tolerant disk group (RAID 1, RAID 5, and RAID 10) and a hot spare is available, the RAID software automatically attempts to rebuild the data to restore redundancy. If no hot spares are available, an automatic rebuild occurs when a new physical disk is installed. You can use MD Storage Manager to specify a physical disk to rebuild.

The requirements for a replacement physical disk are the same as those for a hot spare: the capacity should be equal to or larger than the size of the configured capacity on the physical disk it replaces, including its metadata.

NOTE: For a stripe set of mirrors (RAID 10), it is possible for multiple disks to fail without a virtual disk failure.

Media Errors and Unreadable Sectors

If the RAID controller detects a media error while accessing data from a physical disk that is a member of a disk group with a redundant RAID level (RAID 1, RAID 5 or RAID 10), the controller will try to recover the data from peer disks in the disk group and will use recovered data to correct the error. If the controller encounters an error while accessing a peer disk, it is unable to recover the data and affected sectors are added to the unreadable sector log maintained by the controller.

Other conditions under which sectors are added to the unreadable sector log include:

- A media error is encountered when trying to access a physical disk that is a member of a nonredundant disk group (RAID 0 or degraded RAID 1, RAID 5 or RAID 10).
- An error is encountered on source disks during rebuild.

NOTE: Data on an unreadable sector is no longer accessible.

RAID Operations and Features

This section details the following RAID operations and features supported by your enclosure or RAID controller:

- Virtual disk operations
- Disk group operations
- RAID background operations priority
- Virtual disk migration and roaming

Virtual Disk Operations

Virtual Disk Initialization

Every virtual disk must be initialized. Up to four concurrent initializations can occur for the same RAID controller module.

Background Initialization

The RAID controller module executes a background initialization when the virtual disk is created to establish parity, while allowing full host server access to the virtual disks. Background initialization does not run on RAID 0 virtual disks.

The background initialization rate is controlled by MD Storage Manager. You must stop an ongoing background initialization before you change the rate, or the rate change will not take effect. After you stop background initialization and change the rate, the rate change will take effect when the background initialization restarts automatically.

NOTE: Unlike initialization of virtual disks, background initialization does not clear data from the physical disks.

Foreground Initialization

The RAID controller module firmware supports full foreground initialization for virtual disks. All access to the virtual disk is blocked during the initialization process. During initialization, zeros (0x00) are written to every sector of the virtual disk. The virtual disk is available after the initialization is completed without requiring a RAID controller module restart.

Consistency Check

A consistency check verifies the correctness of data in a redundant array (RAID levels 1, 5, and 10). For example, in a system with parity, checking consistency means computing the data on one physical disk and comparing the results to the contents of the parity physical disk.

A consistency check is similar to a background initialization. The difference is that background initialization cannot be started or stopped manually, while consistency check can.

NOTE: Dell recommends that you run data consistency checks on a redundant array at least once a month. This allows detection and automatic replacement of unreadable sectors. Finding an unreadable sector during a rebuild of a failed physical disk is a serious problem, because the system does not have the redundancy to recover the data.

Media Verification

Another background task performed on the RAID controller module is media verification of all configured physical disks in a disk group. The RAID controller module uses the Read operation to perform verification on the space configured in virtual disks and the space reserved by the controller for the metadata.

Cycle Time

The media verification operation runs only on selected disk groups, independent of other disk groups. *Cycle time* is how long it takes to complete verification of the metadata region of the disk group and all virtual disks in the disk group for which media verification is configured. The next cycle for a disk group starts automatically when the current cycle completes. You can set the cycle time for a media verification operation between 1 and 30 days. The firmware throttles the media verification I/O accesses to disks based on the cycle time.

The RAID controller module tracks the cycle for each disk group independent of other disk groups on the controller and creates a checkpoint. If the media verification operation on a disk group is preempted or blocked by another operation on the disk group, the firmware resumes after the current cycle. If the media verification process on a disk group is stopped due to a RAID controller module restart, the firmware resumes the process from the last checkpoint.

Virtual Disk Operations Limit

The maximum number of active, concurrent virtual disk processes per controller is four. This limit is applied to the following virtual disk processes: background initialization, foreground initialization, consistency check, rebuild, and copy back.

If a redundant controller fails with existing virtual disk processes, the processes on the failed controller are transferred to the peer controller. A transferred process is placed in a suspended state if there are four active processes on the peer controller. The suspended processes are resumed on the peer controller when the number of active processes falls below four.

Disk Group Operations

RAID Level Migration

Over time, you might determine that characteristics of the initial RAID level you set initially are no longer appropriate for your enterprise. For example, you can add fault-tolerant characteristics to a stripe set (RAID 0) by converting it to a RAID 5 set. Select the virtual disk that you want to change and select the type of RAID level to which you want to migrate. MD Storage Manager provides information about RAID attributes to assist you in selecting the appropriate level. You can perform a RAID level migration while the system is still running and without rebooting, which maintains data availability.

Segment Size Migration

Segment size refers to the amount of data (in kilobytes) that the RAID controller module writes on a single physical disk in a virtual disk before writing data on the next physical disk. Valid values for the segment size are 8, 16, 32, 64, 128, 256, and 512 KB.

Dynamic segment size migration enables the segment size of a given virtual disk to be changed. A default segment size was set when the virtual disk was created, based on such factors as the RAID level and expected usage. You can change the default value if actual usage does not match your needs.

When considering a segment-size change, two scenarios illustrate different approaches to the limitations:

- If I/O activity stretches beyond the segment size, you can increase it to reduce the number of disks required to satisfy a single I/O. Using a single physical disk for a single request frees other disks to service other requests, especially when you have multiple users accessing a database or storage environment.
- If you are using the virtual disk in a single-user, large I/O environment (such as for multimedia application storage), performance can be optimized when a single I/O request is serviced with a single data stripe (the segment size multiplied by the number of physical disks in the disk group used for data storage). In this case, multiple disks are used for the same request, but each disk is only accessed once.

Virtual Disk Capacity Expansion

When you configure a virtual disk, you select a capacity based on the amount of data you expect to store. For example, if a disk group will contain a virtual disk that stores larger multimedia files and another virtual disk that stores smaller text files, the multimedia file virtual disk will obviously require more capacity.

However, you might need to eventually increase the virtual disk capacity for a standard virtual disk by adding free capacity to the disk group. This creates more unused space for you to create new virtual disks, or to expand your existing virtual disks.

Disk Group Expansion

Because the storage array supports hot pluggable physical disks, you can add two physical disks at a time for each disk group while the storage array remains online. Data remains accessible on virtual disk groups, virtual disks, and physical disks throughout the entire modification operation. The data and increased unused free space are dynamically redistributed across the disk group. RAID characteristics are also reapplied to the disk group as a whole.

Disk Group Defragmentation

Defragmenting consolidates the free capacity in the disk group into one contiguous area. Defragmentation does not change the way in which the data is stored on the virtual disks.

Disk Group Operations Limit

The maximum number of active, concurrent disk group processes per controller is one. This limit is applied to the following disk group processes: virtual disk RAID level migration, segment size migration, virtual disk capacity expansion, disk group expansion, and disk group defragmentation.

If a redundant controller fails with an existing disk group process, the process on the failed controller is transferred to the peer controller. A transferred process is placed in a suspended state if there is an active disk group process on the peer controller. The suspended processes is resumed when the active process on the peer controller completes or is stopped.

NOTE: If you try to start a disk group process on a controller that does not have an existing active process, the start attempt will fail if the first virtual disk in the disk group is owned by the other controller and there is an active process on the other controller.

RAID Background Operations Priority

The controller supports a common configurable priority for the following RAID operations: background initialization, rebuild, copy back, virtual disk capacity expansion, RAID level migration, segment size migration, disk group expansion, and disk group defragmentation.

The priority of each of these operations can be changed to address performance requirements of the environment in which the operations are to be executed.

NOTE: Setting a high priority level will impact storage array performance. It is not advisable to set priority levels at the maximum level. Priority should also be assessed in terms of impact to host server access and time to complete an operation. For example, the longer a rebuild of a degraded virtual disk takes, the greater the risk for potential secondary disk failure.

Virtual Disk Migration and Disk Roaming

Virtual disk migration is moving a virtual disk or a hot spare from one array to another by detaching the physical disks and re-attaching them to the new array. *Disk roaming* is moving a physical disk from one slot to another on the same array.

Disk Migration

You can move virtual disks from one array to another without taking the target array offline. However, the disk group being migrated must be offline prior to performing the disk migration. If the disk group is not offline prior to migration, the source array holding the physical and virtual disks within the disk group will mark them as missing. However, the disk groups themselves will still be migrated to the target array.

An array can import a virtual disk only if it is in an optimal state. You can move virtual disks that are part of a disk group only if all members of the disk group are being migrated. The virtual disks automatically become available after the target array has finished importing all the disks in the disk group.

When you migrate a physical disk or a disk group from one MD3000i array to another, the MD3000i array you migrate to will recognize any data structures and/or metadata you had in place on the migrating MD3000i array. However, if you are migrating from any other RAID controller, the MD3000i array will not recognize the migrating metadata and that data will be lost. In this case, the RAID controller will initialize the physical disks and mark them as unconfigured capacity.

NOTE: Only disk groups and associated virtual disks with all member physical disks present can be migrated from one storage array to another. Dell recommends that you only migrate disk groups that have all their associated member virtual disks in an optimal state.

NOTE: Migrating disk groups from an MD3000i array to an MD3000 array is not supported.

NOTE: The number of physical disks and virtual disks that a storage array supports limits the scope of the migration.

Use either of the following methods to move disk groups and virtual disks:

- Hot virtual disk migration — Disk migration with the destination storage array power turned on.
- Cold virtual disk migration — Disk migration with the destination storage array power turned off.

NOTE: To ensure that the migrating disk groups and virtual disks are correctly recognized when the target storage array has an existing physical disk, use hot virtual disk migration.

When attempting virtual disk migration, follow these recommendations:

- Moving physical disks to the destination array for migration — When inserting drives into the destination storage array during hot virtual disk migration, wait for the inserted physical disk to be displayed in the MD Storage Manager before inserting the next physical disk.

NOTICE: Without the delay between drive insertions, the storage array can become unstable and manageability is temporarily lost.

- Migrating virtual disks from multiple storage arrays into a single storage array — When migrating virtual disks from multiple, different storage arrays into a single destination storage array, move all of the physical disks from the same storage array as a set into the new destination storage array. Ensure that all of the physical disks from a storage array are migrated to the destination storage array before starting migration from the next storage array.

NOTE: If the drive modules are not moved as a set to the destination storage array, the newly relocated disk groups might not be accessible.

- Migrating virtual disks to a storage array with no existing physical disks — When migrating disk groups or a complete set of physical disks from a storage array to another storage array that has no existing physical disks, turn off the destination storage array. After the destination storage array has been turned on and has successfully recognized the newly migrated physical disks, migration operations can continue.

NOTE: Disk groups from multiple storage arrays should not be migrated at the same time to a storage array that has no existing physical disks. Use cold virtual disk migration for the disk groups from one storage array.

- Enabling premium features before migration — Before migrating disk groups and virtual disks, enable the required premium features on the destination storage array. If a disk group is migrated from a storage array that has a premium feature enabled and the destination array does not have this feature enabled, an `Out of Compliance` error message can be generated. For specific procedures to correct the error, refer to the Recovery Guru.

Disk Roaming

Moving physical disks within an array is called *disk roaming*. The RAID controller module automatically recognizes the relocated physical disks and logically places them in the proper virtual disks that are part of the disk group. Disk roaming is permitted whether the RAID controller module is either online or powered off.

NOTE: The disk group must be offline before moving the physical disks.

Advanced Features

The RAID enclosure supports several advanced features:

- Storage Partitioning, including host server-to-virtual disk mapping
- Virtual Disk Snapshots
- Virtual Disk Copy

NOTE: Virtual Disk Snapshot and Virtual Disk Copy are premium features that must be activated separately. If you have purchased these features, an activation card is supplied that contains instructions for enabling this functionality.

Storage Partitions

Storage partitioning enables host servers to share access to virtual disks in a storage array. A storage partition is a logical entity consisting of one or more virtual disks that can be accessed by a single host server or shared among host servers that are part of a host group. To create a storage partition, you first define a host server or host group, then define a host-to-virtual disk mapping.

NOTE: You must create a storage partition for each type of host.

Storage partitions give multiple host servers or host groups access to the same host server-to-virtual disk mappings. With these mappings, you can control which host server or host group may have access to a virtual disk in your storage array.

The first time you map a virtual disk to a specific host server or host group, a storage partition is created. Any subsequent mappings to that host server or host group do not create new storage partitions.

Under the following conditions, only a single storage partition is required:

- You have only one attached host server that will access all of the virtual disks in the storage array. A single host server can be attached to only one partition.
- You plan to have all attached host servers share access to all virtual disks on the storage array. When you choose this type of configuration, all of the host servers must have the same operating system and must have special software (such as clustering software) to manage virtual disk sharing and accessibility.

If either of the following is true, you *must* use more than one storage partition:

- You want specific host servers to access specific virtual disks in the storage array.
- You have host servers with different operating systems attached to the same storage array.

NOTE: The storage array can support up to 16 storage partitions.

Host Server-to-Virtual Disk Mapping

The host server attached to a storage array accesses various virtual disks on the storage array through its host ports. Specific virtual disk-to-LUN mappings to an individual host server can be defined. In addition, the host server can be part of a host group that shares access to one or more virtual disks.

You can manually configure a host server-to-virtual disk mapping. When you configure host server-to-virtual disk mapping, consider these guidelines:

- You can define one host server-to-virtual disk mapping for each virtual disk in the storage array.
- Host server-to-virtual disk mappings are shared between RAID controller modules in the storage array.
- A unique LUN must be used by a host group or host server to access a virtual disk.
- Not every operating system will have the same number of LUNs available for use.

Host Types

Generally, a host server is a server that accesses a storage array. Host servers are mapped to the virtual disks and use one or more iSCSI initiator ports. In general, host servers have the following attributes:

- **Host name** — A name that uniquely identifies the host server.
- **Host group** (used in Cluster solutions only) — Two or more host servers associated together to share access to the same virtual disks.

  A host group is a group of two or more host servers that share access to specific virtual disks on the storage array. This host group is a logical entity you can create in MD Storage Manager. All host servers in a host group must be running the same operating system.
- **Host type** — The operating system running on the host server.

Snapshot Virtual Disks

A snapshot is a point-in-time image of a virtual disk. The snapshot provides an image of the virtual disk at the time the snapshot was created. Typically, you create a snapshot so that an application (for example, a backup application) can access the snapshot and read the data while the source virtual disk remains online and user-accessible. When the backup is completed, the snapshot virtual disk is no longer needed. You can create up to four snapshots per virtual disk.

Snapshots are used to recover previous versions of files that have changed since the snapshot was taken. Snapshots are implemented using a copy-on-write algorithm, which makes a backup copy of data the instant an error occurs. Data on a virtual disk is copied to the snapshot repository before it is modified.

Snapshots are instantaneous and take up less overhead than a full physical copy process.

For further details on using snapshot virtual disks, see the *MD Storage Manager User's Guide*.

Snapshot Repository Virtual Disk

When you create a snapshot virtual disk, it automatically creates a snapshot repository virtual disk. A snapshot repository is a virtual disk created in the storage array as a resource for a snapshot virtual disk. A snapshot repository virtual disk contains snapshot virtual disk metadata and copy-on-write data for a particular snapshot virtual disk. The repository supports one snapshot only.

You cannot select a snapshot repository virtual disk as a source virtual disk or as a target virtual disk in a virtual disk copy. If you select a Snapshot source virtual disk as the target virtual disk of a virtual disk copy, you must disable all snapshot virtual disks associated with the source virtual disk.

NOTICE: Before using the Snapshot Virtual Disks Premium Feature in a Windows Clustered configuration, you must map the snapshot virtual disk to the cluster node that owns the source virtual disk. This ensures that the cluster nodes correctly recognize the snapshot virtual disk.

Mapping the snapshot virtual disk to the node that does not own the source virtual disk before the Snapshot enabling process is completed can result in the operating system misidentifying the snapshot virtual disk. This, in turn, can result in data loss or an inaccessible snapshot.

For details on mapping the snapshot virtual disk to the secondary node, refer to the *Dell PowerEdge Cluster SE600W Systems Installation and Troubleshooting Guide* on **support.dell.com**.

Virtual Disk Service

The Microsoft Virtual Disk Service (VDS) is supported on your RAID storage array. Microsoft VDS is a set of application programming interfaces (APIs) that provides a single interface for managing disks and other storage hardware, including creating volumes on those disks.

The Microsoft VDS installer service for storage provisioning is available on the *MD3000i Resource CD* in the **\windows\VDS_VSS** directory. For more information on VDS, see **www.microsoft.com**.

NOTE: When registering VDS during your Windows setup, the registration graphical user interface (GUI) prompts you to provide the name of your array because settings in the GUI are array-specific, not host-specific.

Volume Shadow-Copy Service

The Microsoft Volume Shadow-copy Service (VSS) is a storage management interface for Microsoft Windows Server® 2003. VSS enables your storage array to interact with third-party applications that use the VSS Application Programming Interface. Microsoft VSS is included in the Windows Server 2003 installation.

NOTE: A volume is another term for virtual disk.

VSS attaches to the service and uses it to coordinate the creation of snapshot virtual disks on the storage array. VSS-initiated snapshot virtual disks can be triggered through backup tools, known as *requestors*. The VSS Provider Configuration Tool makes available the following configuration options:

- **Snapshot Repository Virtual Disk Properties** — This section contains a drop-down list for the RAID level and a field for entering source virtual disk capacity percentage for snapshot repositories.
- **Snapshot Repository Virtual Disk Location** — This section contains a list of preferences for the location of the snapshot repository virtual disk. These preferences are honored whenever conditions permit.

The Microsoft VSS installer service for storage provisioning is available on the *MD3000i Resource CD* in the **\windows\VDS_VSS** directory.

NOTE: When registering VSS during your Windows setup, the registration graphical user interface (GUI) prompts you to provide the name of your array because settings in the GUI are array-specific, not host-specific.

Storage Management VSS Hardware Provider Tips:

- The number of snapshot virtual disks that can be created using a single snapshot set varies with the I/O load on the RAID controller modules. Under little or no I/O load, the number of virtual disks in a snapshot set should be limited to eight. Under high I/O loads, the limit should be three.
- The snapshot virtual disks created in the storage management software are differential snapshots. Plex snapshots are not supported.
- Virtual disks to be used as source virtual disks for VSS snapshots should have names no longer than 16 characters. The VSS hardware provider uses the base virtual disk name as a prefix for the snapshot and repository virtual disk names. The resulting snapshot and repository names will be too long if the source virtual disk name exceeds 16 characters.

Virtual Disk Copy

Virtual Disk Copy is a premium feature you can use to back up data, copy data from disk groups that use smaller-capacity physical disks to disk groups using greater capacity physical disks, or restore snapshot virtual disk data to the source virtual disk. Virtual Disk Copy generates a full copy of data from the source virtual disk to the target virtual disk in a storage array.

Source Virtual Disk — When you create a virtual disk copy, a copy pair consisting of a source virtual disk and a target virtual disk is created on the same storage array. When a virtual disk copy is started, data from the source virtual disk is copied completely to the target virtual disk.

Target Virtual Disk — When you start a virtual disk copy, the target virtual disk maintains a copy of the data from the source virtual disk. You can choose whether to use an existing virtual disk or create a new virtual disk as the target virtual disk. If you choose an existing virtual disk as the target, all data on the target is overwritten. A target virtual disk can be a standard virtual disk or the source virtual disk of a failed or disabled snapshot virtual disk.

NOTE: The target virtual disk capacity must be equal to or greater than the source virtual disk capacity.

When you begin the disk copy process, you must define the rate at which the copy is completed. Giving the copy process top priority will slightly impact I/O performance, while giving it lowest priority will make the copy process take longer to complete. You can modify the copy priority while the disk copy is in progress.

You can find more details on using the virtual disk copy feature in the *MD Storage Manager User's Guide*.

Virtual Disk Recovery

You can use the **Edit host server-to-virtual disk mappings** feature to recover data from the backup virtual disk. This functionality enables you to unmap the original source virtual disk from its host server, then map the backup virtual disk to the same host server.

Ensure that you record the LUN used to provide access to the source virtual disk. You will need this information when you define a host server-to-virtual disk mapping for the target (backup) virtual disk. Also, be sure to stop all I/O activity to the source virtual disk before beginning the virtual disk recovery procedure.

Using Snapshot and Disk Copy Together

You can use the Snapshot Virtual Disk and Virtual Disk Copy premium features together to back up data on the same storage array, or to restore the data on the snapshot virtual disk to its original source virtual disk.

You can copy data from a virtual disk in one of two ways:

- By taking a point-in-time snapshot of the data
- By copying the data to another virtual disk using a virtual disk copy

You can select a snapshot virtual disk as the source virtual disk for a virtual disk copy. This configuration is one of the best ways you can apply the snapshot virtual disk feature, since it enables complete backups without any impact to the storage array I/O.

You cannot, however, use a snapshot repository virtual disk as a source virtual disk or as a target virtual disk in a virtual disk copy. If you select the source virtual disk as the target virtual disk of a virtual disk copy, you must disable all snapshot virtual disks associated with the source virtual disk.

Hardware Redundancy and Failover

This section provides basic information on how to connect a host server to the RAID controller modules in a RAID enclosure in order to achieve redundancy and failover.

NOTE: The best practice for ensuring data access is to avoid a configuration with a single point of failure. A single point of failure is any component or path that is not duplicated (redundant) or whose failure can cause loss of data access.

Redundancy and Non-Redundancy

Redundancy means that a storage array has duplicate components, or alternate ways to provide essential services. This redundancy ensures access to the virtual disks in case of a failure of a single component.

In a typical RAID configuration, most of the components are redundant; however, the configuration itself might not be fully redundant. For example, there might be components whose individual failure would cause loss of access to the virtual disks. In a fully redundant storage array, all components must be duplicated. In addition, the storage array must be configured in such a way as to ensure that duplicate components can be accessed in case of a failure.

The manner in which the storage array is cabled is essential for creating a successfully configured redundant storage array. Refer to the *PowerVault MD3000i Installation Guide* for examples of how to cable your host servers for redundancy. After you have made a physical connection between your MD3000i and host server, establish communication by using the iSCSI software initiator on the host server to log in to the MD3000i target. For more information on configuring your iSCSI connections, refer to the *PowerVault MD Storage Manager CLI Guide*.

Multi-Path Software

Multi-path software (also referred to as the failover driver) is software resident on the host server that provides management of the redundant data path between the host server and the RAID enclosure. For the multi-path software to correctly manage a redundant path, the configuration must provide for redundant iSCSI connections and cabling.

The multi-path software identifies the existence of multiple paths to a virtual disk and establishes a preferred path to that disk. If any component in the preferred path fails, the multi-path software automatically re-routes I/O requests to the alternate path so that the storage array continues to operate without interruption.

NOTE: Multi-path software is included with MD Storage Manager.

Preferred and Alternate Controllers and Paths

A *preferred* controller is a RAID controller module designated as the owner of a virtual disk or disk group. The preferred controller is automatically selected by MD Storage Manager when a virtual disk is created. You can change the preferred RAID controller module owner of a virtual disk after it is created.

Ownership of a virtual disk is moved from the preferred controller to the second controller (also called the *alternate controller*) when the preferred controller is:

- Physically removed
- Updating firmware
- Involved in a fatal event that caused failover to the alternate controller

Paths used by the preferred controller to access either the disks or the host server are called the *preferred paths*; redundant paths are called the *alternate paths*. If a failure causes the preferred path to become inaccessible, the storage array automatically uses the alternate path to access data.

When a RAID Controller Module Is Replaced or Removed

When one RAID controller module fails, or is removed from the RAID enclosure, failover software on the host server directs the alternate RAID controller module to assume all controller responsibilities for the storage array. The virtual disks owned by the failed or removed RAID controller module are failed over to the surviving controller and no data is lost.

NOTE: For Linux kernels, stop and then restart the SMagent after moving a controller offline, replacing a controller, or configuring iSCSI connections.

Because host-based multi-path software is configured for automatic failback, the data paths and virtual disks are restored to their original RAID controller module after the RAID controller module is replaced.

Automatic failback occurs under the following conditions:

- Data is protected by dual redundant paths to the host server.
- The host server has multi-path failover software installed, and it is configured for auto failback.

- Failover occurred due to either RAID controller module lockdown, replacement, or path failover.

NOTE: Clustering requires simultaneous access from cluster nodes to shared storage. If you have clustering software installed on the host server, automatic failback should be disabled to prevent "ping-pong" with single-path failure. For more information on clustering, a link to clustering documentation is included on the *MD3000i Resource CD* under Product Documentation.

RAID Controller Failover Modes

Failover provides redundant access to the virtual disks owned by either RAID controller module on the storage array. Failover happens automatically (and transparently). As a result, the host server(s) never loses access through the preferred controller that owns the virtual disk.

Two failover modes are supported:

- Host-based Multi-Path I/O (MPIO) for Windows or MPP for Linux
- Controller-based Auto Virtual Disk Transfer (AVT)

Host-based uses a multi-path driver installed on the host server to access the storage array. If required, the multi-path driver will issue an explicit command to transfer ownership from the RAID controller module that owns the virtual disk to its peer RAID controller module.

AVT is used only in single-port cluster solutions. I/O access to the Logical Unit Number (LUN) of a virtual disk causes failover. In AVT mode, firmware transfers ownership of a virtual disk to the online RAID controller module. The alternate or backup node in a cluster takes over and issues I/O to the peer controller and moves the virtual disk to itself.

NOTE: Clustering requires simultaneous access from cluster nodes to shared storage. If you have clustering software installed on the host server, automatic failback should be disabled to prevent "ping-pong" with single-path failure. For more information on clustering, a link to clustering documentation is included on the *MD3000i Resource CD* under Product Documentation.

NOTE: If setting up a cluster host, the **MD3000i Stand Alone to Cluster.reg** file entry must be merged into the registry of each node. If re-configuring a cluster node to a standalone host server, the **MD3000i Cluster to Stand Alone.reg** file must be merged into the host registry. These registry files, which set up the host server for correct failback operation, are in the **windows\utility** directory of the *MD3000i Resource CD*.

Thermal Shutdown

Enclosure management provides a feature which automatically shuts down the enclosure when the temperature within the RAID enclosure reaches dangerous extremes. Thermal shutdown protects the data on the physical disks from corruption in the event of a cooling system failure.

The temperature at which shutdown occurs is determined by the enclosure temperature probe's Nominal Failure Threshold and the Maximum Failure Threshold. These thresholds are default settings that cannot be changed. If the temperature sensors on the backplane detect a temperature exceeding the Nominal Failure Threshold, a critical event is set. If the Maximum Failure Threshold is reached, shutdown of the enclosure power supplies occurs within 3 minutes. A third threshold, the Shutdown Threshold, shuts down the enclosure power supplies within 5 seconds after it is reached.

NOTE: If an MD1000 expansion enclosure reaches critical internal temperatures, the enclosure will be shut down automatically via a thermal shutdown command issued by the EMM firmware.

Updating Enclosure Firmware

You can use MD Storage Manager to upgrade the firmware for the RAID controller module, the controller NVSRAM, and the physical disks. In a redundant configuration, the RAID controller module firmware can be upgraded with no interruption to data access.

RAID Controller Module Firmware

The RAID controller module firmware and NVSRAM files are needed to properly use MD Storage Manager and all of its features.

Before you download the RAID controller module firmware or NVSRAM files, ensure that the multi-path driver (for example, MPP for Linux or MPIO for Windows) is running on the host server. In a redundant configuration, the multi-path driver maintains data access through one RAID controller module while the other RAID controller module's firmware is upgraded. Also check the MD Storage Manager to see if it lists both RAID controller modules as

optimal. Downloading firmware when either or both controllers are non-optimal may result in unsynchronized firmware and cause you to have to run the download again after restoring the RAID controller module(s) to optimal condition.

If a RAID controller is replaced and its firmware does not match the version on the non-replaced RAID controller, the non-replaced controller will automatically flash the replacement controller with its firmware version to ensure that both controllers have the same firmware version.

NVSRAM Update

NVSRAM packages specify the internal settings for the storage array RAID controller modules. These internal settings cannot be modified except by an NVSRAM update. You can download RAID controller module firmware and NVSRAM packages separately or together using MD Storage Manager.

Physical Disk Firmware

NOTE: Dell recommends stopping all I/O to the array when downloading physical disk firmware.

You can also download physical disk packages containing the latest firmware files. Ensure that the firmware files you select are compatible with the physical disks.

Before downloading firmware, you should back up all your data. In addition, do not make any configuration changes to the storage array, such as creating virtual disks or defining host servers, during the download. Doing so could cause the firmware download to fail and prevent access to the physical disks.

Expansion Enclosure Firmware

You can download firmware updates for your MD1000 expansion enclosures using the MD Storage Manager.

Best Practices and Recommendations

The MD3000i RAID array supports a variety of configurations. To take full advantage of its iSCSI features and achieve optimal performance, consider the following recommendations.

- Use a separate network for all your iSCSI storage needs. If a separate network cannot be dedicated, assign this storage function to a separate virtual local area network (VLAN), which creates independent logical networks within a physical network.

  NOTE: Use untagged VLANs for your storage needs. VLAN tagging is not supported.

- Use a separate subnet for each iSCSI controller port.
- Disable the **File and printer sharing for Microsoft Networks** option in the IP stack of those network interface cards (NICs) of your host that will be dedicated as iSCSI storage initiators.
- For a secure network, use separate, dedicated Ethernet switches for all iSCSI activity. If your iSCSI traffic travels on the same switch fabric as public Ethernet data or across the Internet, set up Challenge Handshake Authentication Protocol (CHAP) security to authenticate all access to the iSCSI ports on both the host server and the storage array. Refer to the *PowerVault MD3000i Installation Guide* for information on configuring CHAP.
- Refer to the *User's Guide* for information on configuring your iSCSI host servers to use with storage arrays in a storage area network (SAN). Advanced setting considerations for iSCSI target parameters are included.

  NOTE: Changing any of these settings resets the iSCSI port. I/O is interrupted to any host server accessing that port. You can access the I/O automatically after the port restarts and the host server logs in again.

3

Installing Enclosure Components

This section explains how to install the following components:

- Front bezel (optional)
- Physical disks and disk carriers
- RAID controller modules
- Battery backup unit
- Power supplies
- Control panel
- Enclosure midplane

Recommended Tools

The procedures in this section require the use of one or more of the following tools:

- #2 Phillips-head screwdriver
- Torx T10 driver
- Wrist grounding strap, as explained in the safety instructions found in your *Product Information Guide*

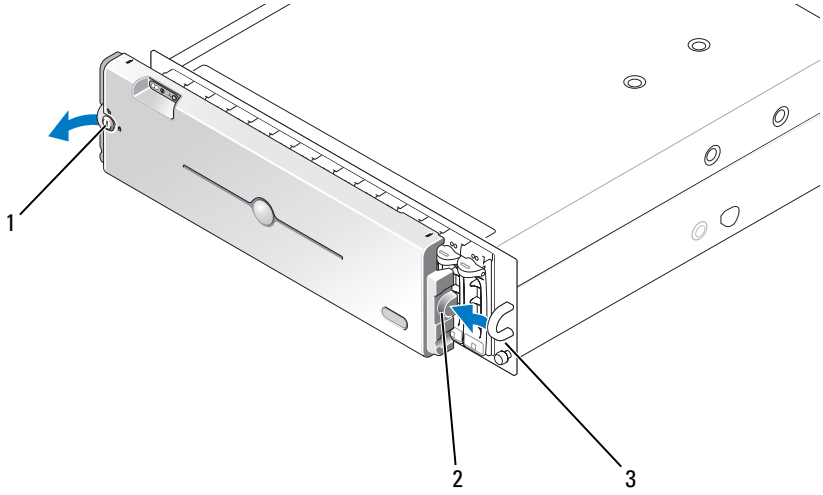
Removing and Replacing the Front Bezel

To access the physical disks in your enclosure, you must remove the optional front enclosure bezel. If your enclosure does not have this bezel, skip this section.

To remove the bezel:

1. If the bezel is locked, insert the bezel locking key in the bezel lock. If the bezel is unlocked, go to step 3.
2. Turn the key to the left to unlock the bezel.
3. Push inward on the release tab on the bezel and lift it away from the enclosure front (see Figure 3-1).

Figure 3-1. Installing and Removing the Front Bezel



1 bezel lock 2 release tab/interlocking notch 3 U-shaped handle

4 To replace the bezel, insert the interlocking notch into the U-shaped handle on the side of the front enclosure panel.

5 Snap the left side of the bezel into place in the U-shaped handle on the left side of the enclosure.

6 To lock the bezel, insert the key and turn to the right.

Removing and Installing Physical Disks

Your enclosure supports up to 15 SAS 3.0-Gbps physical disks, each one contained in its individual disk carrier. Physical disks are connected directly to the enclosure midplane and are hot-pluggable, allowing you to remove and insert disks without shutting down your enclosure.

This section describes how to remove and install physical disks in your storage array.

NOTICE: Extra care must be taken when handling and storing the physical disks. The carriers provide some protection, but the disks and carrier connectors can be damaged by rough handling. When removing the physical disks from the enclosure, place them on a padded surface. Never drop the disks.

Removing Physical Disks from the Enclosure

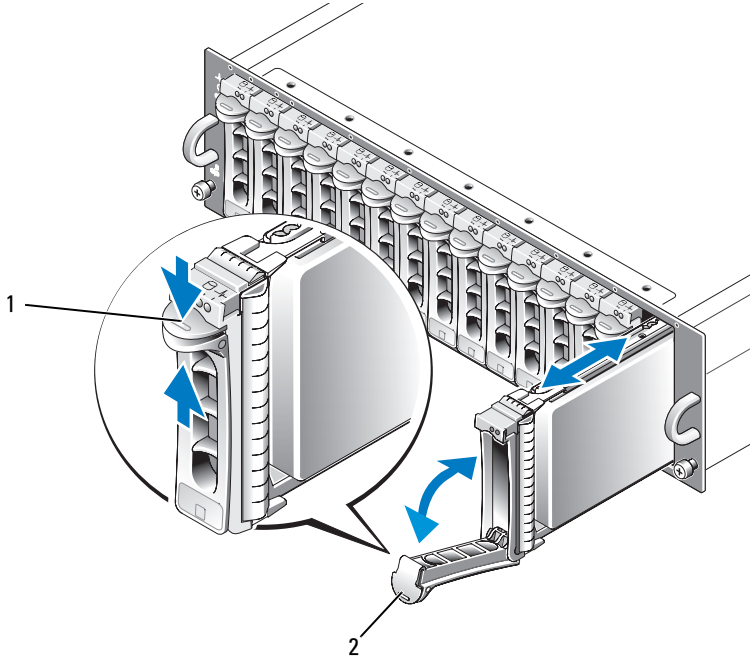
NOTICE: To avoid damage, never leave a physical disk carrier partially removed from the enclosure. Rotating a carrier handle next to an unseated disk carrier will result in serious damage to the unseated disk carrier.

NOTICE: To avoid data loss when removing a physical disk, Dell recommends that you verify with MD Storage Manager that the appropriate disk is being removed. Removing an Assigned physical disk could result in data loss.

CAUTION: Always wear a wrist grounding strap when handling equipment with static-sensitive components.

1. Wait until the LED indicators on the physical disk carrier stop flashing.
2. Squeeze the release mechanism on the front of the physical disk carrier (see Figure 3-2).

Figure 3-2. Installing and Removing Physical Disks



1 carrier release mechanism 2 disk carrier handle

3 Open the physical disk carrier handle by rotating it downward.

4 Gently but firmly pull the physical disk carrier from its slot while supporting the weight of the disk from the bottom.

Installing SAS Physical Disks in the Enclosure

NOTICE: To ensure proper airflow for enclosure cooling, each slot should contain either an active physical disk or a disk blank.

CAUTION: Always wear a wrist grounding strap when handling equipment with static-sensitive components.

1 Perform the following steps to install the new physical disk into the carrier:

NOTE: Data from virtual disks created on a PERC RAID controller cannot be migrated to an MD3000i or to an MD1000 expansion enclosure connected to an MD3000i.

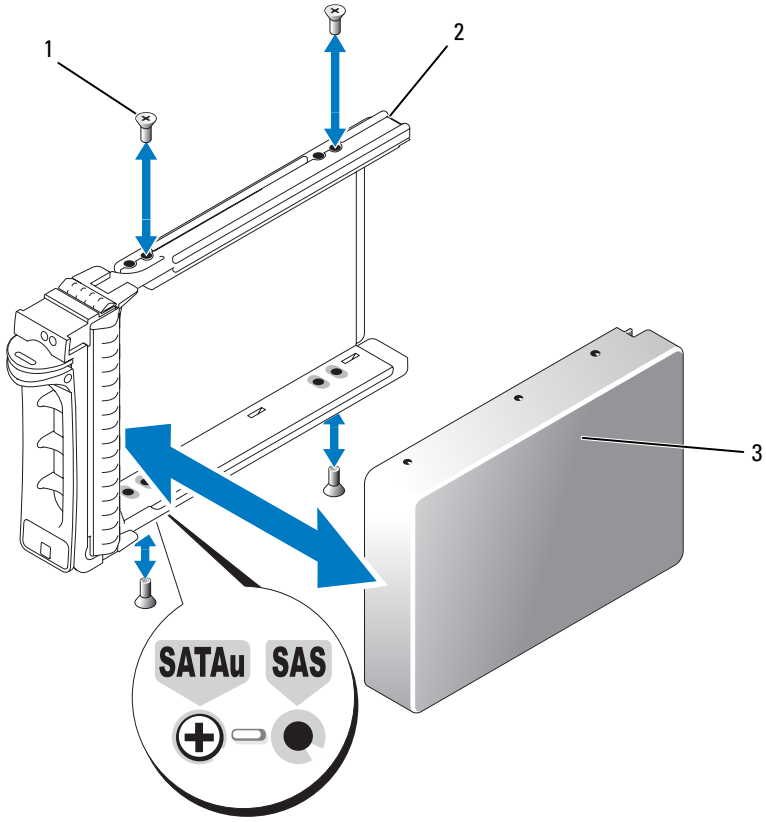
a If you are replacing a physical disk in the carrier, remove the four screws that secure the disk to its carrier and remove the disk (see Figure 3-3).

b Position the replacement physical disk into the disk carrier with the disk's controller board facing the rear of the carrier.

c From the rear of the carrier, slide the physical disk into the carrier until it contacts the stop tab at the front of the carrier.

d Secure the physical disk to the carrier using the four screws removed earlier. To avoid damaging the carrier, do not overtighten.

Figure 3-3. Installing a SAS Physical Disk in the Carrier



1 screws (4) 2 physical disk carrier 3 physical disk

2 With the physical disk carrier handle open, carefully align the channel on the disk carrier guide rail with the appropriate disk slot keying feature on the chassis face plate, and insert the disk (see Figure 3-2).

3 Push the physical disk carrier into the slot until the bottom of the open carrier handle makes contact with the chassis face plate.

4 Rotate the carrier handle to the closed position while continuing to push the carrier into the slot.

The status LED indicator (see Table 1-3 for description) will display a steady green if the physical disk is inserted properly. If the indicator is not illuminated, see "Troubleshooting SAS Physical Disks" on page 76.

NOTE: At least two physical disks must be installed in the enclosure.

Removing and Installing a RAID Controller Module

The enclosure contains two RAID controller modules. Both are hot-pluggable and can be removed and installed independently without shutting down the enclosure.

NOTICE: Removing a module is not recommended while data traffic involving that module is occurring. Although RAID controller modules are hot-pluggable, data loss could result from removing a module involved in data traffic.

CAUTION: Always wear a wrist grounding strap when handling equipment with static-sensitive components. See your *Product Information Guide* for safety information.

Removing a RAID Controller Module

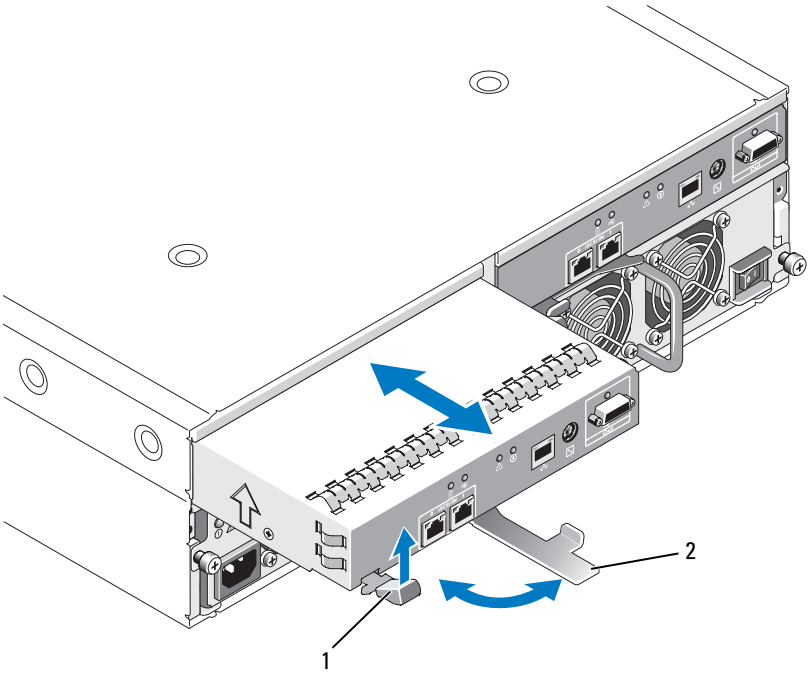
1 Push up on the release tab on the left side of the module (see Figure 3-4).

2 At the same time, pull out on the release lever. When the lever is pulled out, the controller module partially ejects from the enclosure.

3 Remove the module from the enclosure and place it on a flat, secure surface.

NOTICE: To avoid damage to the sensitive EMI contacts on the bottom of the controller module, do not stack or place it on a hard surface.

Figure 3-4. Removing and Installing a RAID Controller Module



1 release tab 2 release lever

Installing a RAID Controller Module

1. Carefully insert the RAID controller module into the empty module slot.
2. Push the module to the back of the slot until it is firmly seated in the backplane connector (see Figure 3-4).
3. Push the release lever in (towards the enclosure) until the module is retracted into the slot and is secure.

For information on controller connections and cabling, see the *PowerVault MD3000i Installation Guide*.

Removing and Installing a RAID Controller Module Backup Battery Unit

Each RAID controller module has a battery unit that provides backup power for the data cache memory. The battery unit is mounted inside the RAID controller module and connects to the controller circuit board. This section describes how to remove and replace the battery unit.

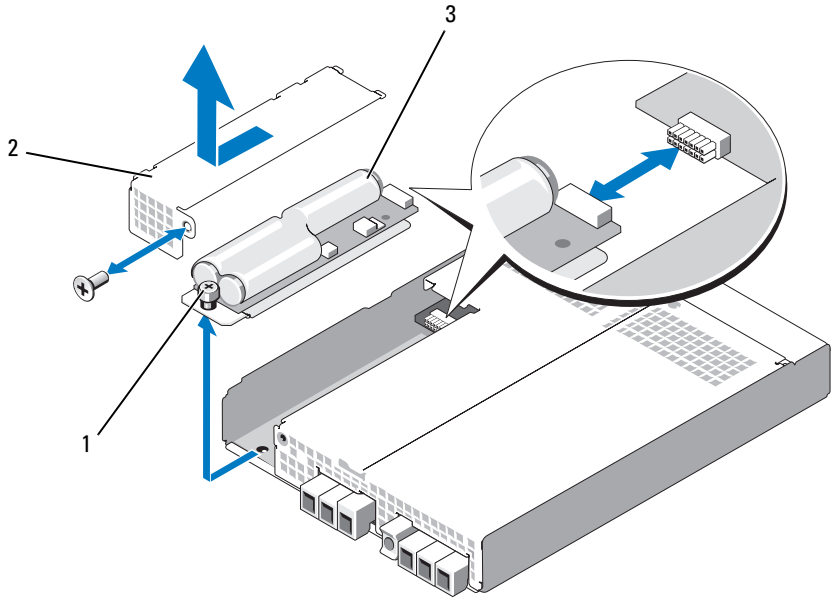
CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.

NOTICE: RAID controller modules are hot-pluggable and can be removed and installed without shutting down the enclosure. However, removing a controller module on which data traffic is occurring could cause data loss and is not recommended. Use the MD Storage Manager to take the RAID controller module offline before removal.

CAUTION: Always wear a wrist grounding strap when handling equipment with static-sensitive components. See your *Product Information Guide* for safety information.

1. Use MD Storage Manager to place the RAID controller module offline. See the MD Storage Manager documentation for more information.
2. Remove the RAID controller module (see "Removing and Installing a RAID Controller Module" on page 60).
3. Remove the screws holding the battery cover and remove the cover (see Figure 3-5).

Figure 3-5. Removing and Installing a RAID Controller Module Backup Battery Unit



1	thumbscrew	2	battery cover	3	battery unit

4. Unscrew the thumbscrew holding the battery unit to the controller module.
5. Disconnect the battery unit from the connector by sliding it towards the back of the controller, then remove it from the controller module.
6. Place the replacement battery unit into the controller module tray and push the battery unit into the connector on the RAID controller circuit board.
7. Tighten the thumbscrew to secure the battery unit to the controller.
8. Reinstall the battery cover.
9. Reinstall the RAID controller module (see "Installing a RAID Controller Module" on page 61).
10. Reset the battery installation date using MD Storage Manager.

Removing and Installing the Power Supply/Cooling Fan Module

Your enclosure supports two separate modules containing an integrated power supply and two cooling fans per module. While the enclosure can operate temporarily with only one functional power supply, both cooling modules (with two fans each) must be present for proper cooling. Three of the four fans must be operational for the enclosure to avoid overheating.

NOTICE: A single power supply/cooling fan module can be removed from a powered-on enclosure for a maximum period of 5 minutes. Beyond that time, the enclosure may automatically shut down to prevent damage.

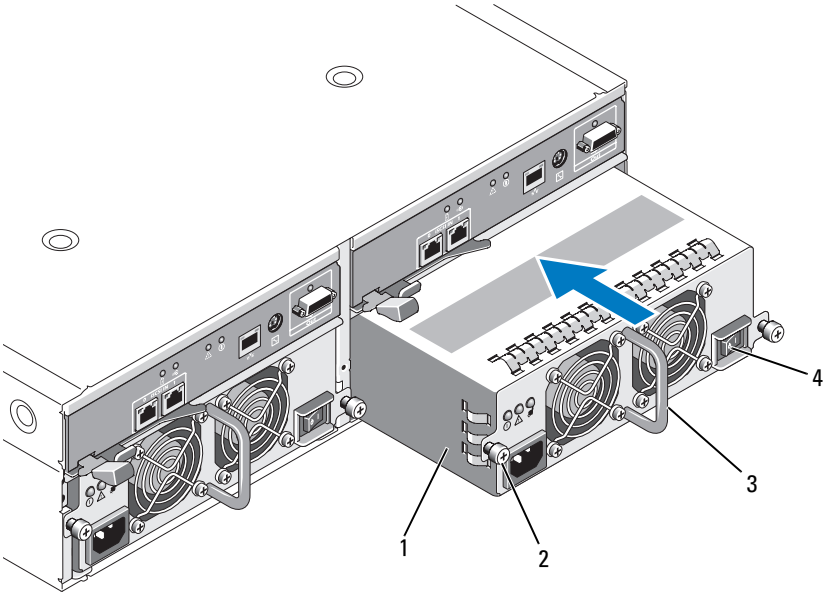
Removing a Power Supply/Cooling Fan Module

NOTICE: Power supply/cooling fan modules are hot-pluggable. Provided one power supply/cooling fan module is functioning normally, you can remove or replace the other while the enclosure is powered on.

NOTE: If you remove a fully functioning power supply/cooling fan module, the fan speed in the remaining module will increase significantly to provide adequate cooling. The fan speed will decrease gradually when a new power supply/cooling fan module is installed.

1. Turn off the power supply you intend to remove using the on/off switch.
2. Using a Phillips-head screwdriver, loosen the two captive screws securing the power supply/cooling fan module in the bay (see Figure 3-6).

Figure 3-6. Replacing the Power Supply



1	power supply	2	captive screws (2)	3	handle
4	on/off switch				

CAUTION: The power supply/cooling fan modules are heavy. Use both hands when removing.

3 Grasp the handle on the power supply and carefully pull the module out of the bay (see Figure 3-6).

NOTICE: The power-supply handle is provided to ease the task of pulling the module from the bay. Do not use this handle to carry the module.

Installing a Power Supply/Cooling Fan Module

1 Carefully slide the new power supply/cooling fan module approximately two-thirds of the way into the empty bay.

2 Gently push the module all the way to the back of the bay until it is firmly seated in the backplane connector.

The power supply is seated when its front plate is even with the front plate of the adjacent power supply.

NOTE: If the enclosure is powered on, the power-supply fault indicator (see Figure 1-7) remains illuminated until you connect the AC power cable to the power supply and turn on the on/off switch.

3 Tighten the two captive screws to secure the new power supply/cooling fan module in the bay.

4 Connect the AC power cable to the new power supply and to an electrical outlet.

5 Turn on the on/off switch on the new power supply.

Removing and Installing the Control Panel

The control panel powers the LED indicators on the front panel of the system enclosure. It is connected to the backplane and cannot be removed or replaced unless the system is powered down.

CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.

Removing the Control Panel

1 Power down your host server.

2 Power down your enclosure.

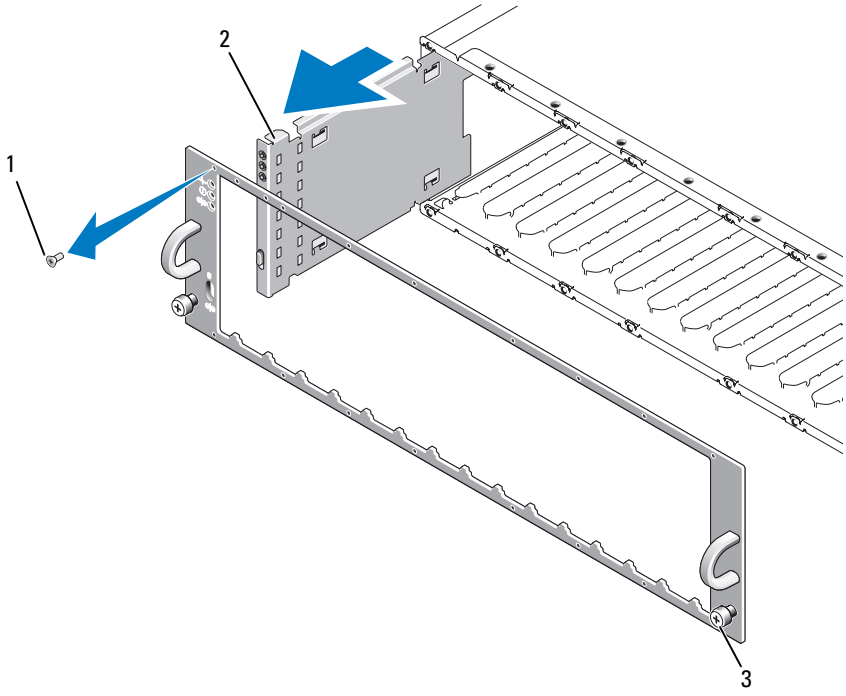
3 Disconnect all power cables to the enclosure.

4 Loosen the two thumbscrews on the front of the enclosure panel and pull the enclosure approximately six inches out from the rack (see Figure 3-7).

5 Remove all the physical disks from the enclosure (see "Removing and Installing Physical Disks" on page 56).

NOTE: To avoid confusion when re-installing the disks, mark each one with its slot position as you remove it.

Figure 3-7. Removing and Replacing the Control Panel



1 faceplate screws (16) 2 control panel 3 thumbscrews

6 Using a Torx T10 driver, remove all 16 screws from the front faceplate of the enclosure as shown in Figure 3-7.

7 Remove the front faceplate from the enclosure and place it on a flat, secure surface.

8 Slide the control panel assembly straight out from its connector on the backplane (see Figure 3-7).

Installing the Control Panel

1 Align the top and bottom tabs on the control panel with the insert slots on the edge of the chassis (see Figure 3-7).

2 Slide the control panel fully into the slot, making sure that its connector engages into the matching backplane connector (see Figure 3-7). Also, make sure the guide tab on the control panel is fully inserted into the mounting slot on the backplane.

3 Replace the front faceplate and re-attach the 16 screws that hold it in place.

4 Re-install any physical disks you removed (see "Removing and Installing Physical Disks" on page 56).

5 Push the enclosure all the way back into the rack and tighten the thumbscrews.

6 Reconnect power cables to the enclosure and power it back on.

7 Power on the host server.

Removing and Installing the Midplane

CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.

The enclosure midplane contains the connectors for the physical disks, RAID controller module, control panel, and power supply/cooling fan modules.

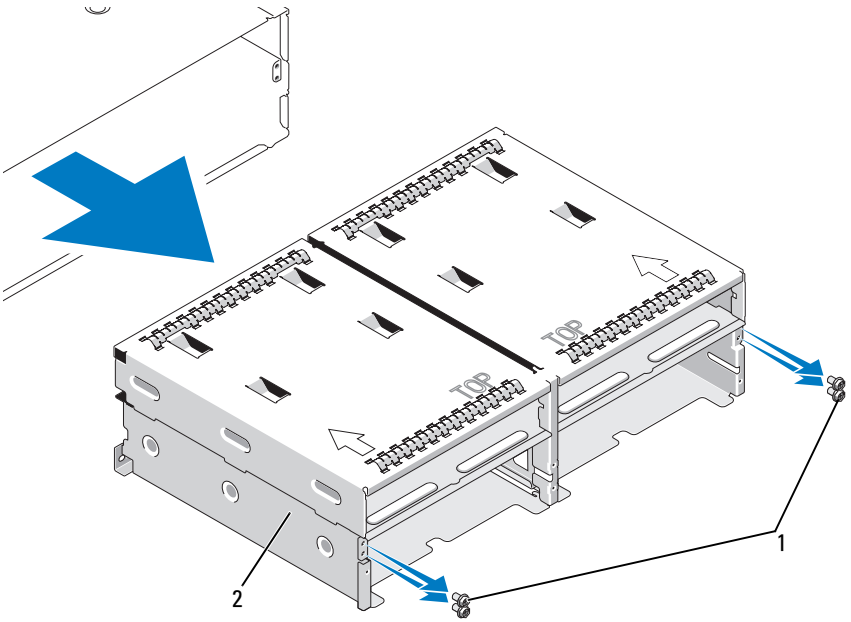
1 Complete the steps in "Removing the Control Panel" on page 66.

2 Remove the RAID controller modules from the enclosure. (See "Removing and Installing a RAID Controller Module" on page 60.)

3 Remove both power supply/cooling fan modules from the enclosure. (See "Removing and Installing the Power Supply/Cooling Fan Module" on page 64.)

4 Remove the four Phillips screws holding the controller/power supply cage in the enclosure (see Figure 3-8).

Figure 3-8. Removing and Replacing the Controller/Power Supply Cage



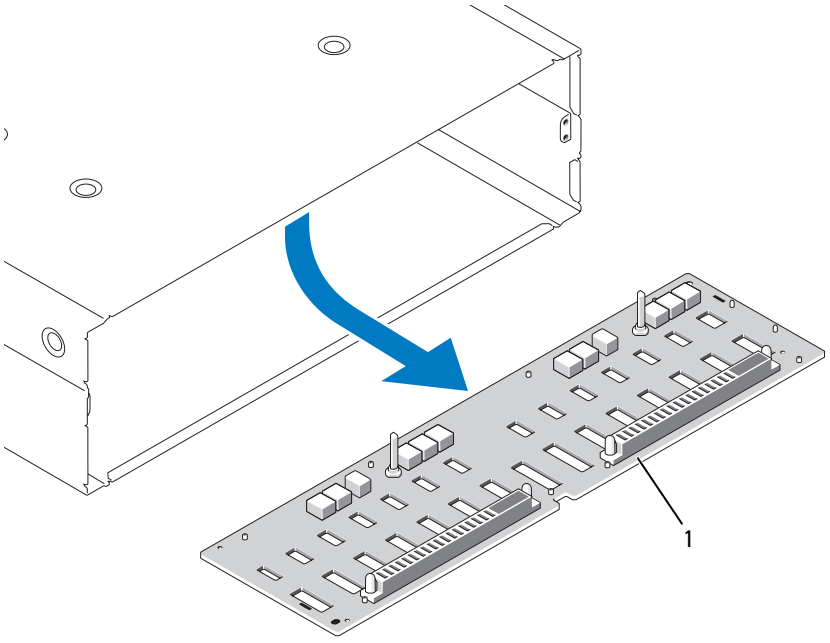
1 Phillips screws (4) 2 controller/power supply cage

5 Slide the controller/power supply cage out of the enclosure and place it aside.

6 Reaching into the enclosure chassis from the back, carefully disconnect the midplane from the control panel and lift it out of the enclosure (see Figure 3-9).

7 To re-install the midplane, reverse the previous steps.

Figure 3-9. Removing and Installing the Midplane



1 midplane

4

Troubleshooting Your Enclosure

Safety First—For You and Your Enclosure

To perform certain procedures in this document, you must work inside the enclosure. While working inside the enclosure, do not attempt to perform service except as explained in this guide and elsewhere in your documentation.

CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.

Start-Up Routine

Look and listen during the enclosure's start-up routine for the indications described in Table 4-1. For a description of the front- and back-panel indicators, see "About Your System" on page 9.

Table 4-1. Start-Up Routine Indications

Look/listen for:	Action
Alert messages.	See your storage management documentation.
An unfamiliar constant scraping or grinding sound when you access a physical disk.	See "Getting Help" on page 81.

NOTE: At least two physical disks must be installed in the enclosure.

Troubleshooting External Connections

Loose or improperly connected cables and bent pins are the most likely source of problems. Ensure that all external cables are securely attached to the external connectors on your system and that none of the connectors are damaged. See "Back-Panel Indicators and Features" on page 18 for the back-panel connectors on your enclosure.

Troubleshooting a Wet Enclosure

Problem

- Liquid spilled on the enclosure.
- Excessive humidity.

Action

CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.

1. Turn off the enclosure and disconnect all power.
2. Remove all the physical disks from the enclosure. See "Removing and Installing Physical Disks" on page 56.
3. Remove the RAID controller modules from the enclosure. See "Removing and Installing a RAID Controller Module" on page 60.
4. Remove the power supply/cooling fan modules from the enclosure. See "Removing and Installing the Power Supply/Cooling Fan Module" on page 64.
5. Remove the enclosure midplane. See "Removing and Installing the Midplane" on page 68.
6. Let the enclosure dry thoroughly for at least 24 hours.
7. Reinstall all the components you removed in the previous steps.
8. Reconnect the enclosure to the electrical outlet and turn on the enclosure.

   If the enclosure does not start properly, see "Getting Help" on page 81.

Troubleshooting a Damaged Enclosure

Problem

- Enclosure was dropped or damaged.

Action

CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.

1. Ensure that the following components are present, not broken, and properly installed:
   - All physical disks (both in their carriers and connected to the enclosure midplane)
   - Power supply/cooling fan modules
   - RAID controller modules
   - Enclosure midplane
2. Ensure that all cables are properly connected and that there are no bent pins in the connector.

   If problems are encountered, see "Getting Help" on page 81.

Troubleshooting Power Supplies

Problem

- Enclosure-status indicators show a problem.
- Power-supply fault indicators are lit.

Action

CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.

1. Check that at least two physical disks are present in the enclosure. A minimum of two physical disks must be installed. If they are not, install the minimum number of physical disks. If the problem persists, go to step 3.
2. Referring to the Recovery Guru procedure of the MD Storage Manager, locate the faulty power supply and note the status of the LEDs.

   If the AC Power LED is not lit, troubleshoot the power cord and power source into which the power supply is plugged.

   - Use a known good power source (outlet).
   - Use a known good power cord.

   If the DC power LED is not lit, verify that the power switch is turned on. If the power switch is turned on, continue to step 3.

   If the power supply's fault indicator is lit, continue to step 3.
3. Ensure that the power supply is properly installed by removing and re-installing it. See "Removing and Installing the Power Supply/Cooling Fan Module" on page 64.

   NOTE: After installing a power supply, allow several seconds for the enclosure to recognize the power supply and determine if it is working properly.

   NOTICE: Power supply/cooling fan modules are hot-pluggable. The enclosure can operate on a single functioning power supply; however, both modules must be installed to ensure proper cooling. A single power supply/cooling fan module can be removed from the enclosure for up to 5 minutes, provided the other module is functioning properly. After 5 minutes, the enclosure will overheat and may cause an automatic thermal shutdown.
4. If the problem is resolved, skip the rest of this procedure.

   If the problem persists, remove the faulty power supply. See "Removing and Installing the Power Supply/Cooling Fan Module" on page 64.

5 Install a new power supply. See "Removing and Installing the Power Supply/Cooling Fan Module" on page 64.

If the problem persists, see "Getting Help" on page 81.

Troubleshooting Enclosure Cooling Problems

Problem

- MD Storage Manager issues a fan-related error message.
- MD Storage Manager issues a temperature-related error message.

Action

Ensure that none of the following conditions exists:

- Ambient temperature is too high.
- External airflow is obstructed.
- A power supply/cooling fan module has failed. See "Troubleshooting a Fan" on page 75.

Troubleshooting a Fan

Problem

- Enclosure-status indicator is amber.
- Systems management software issues a fan-related error message.
- Fan status indicator indicates a problem with the fan.

Action

CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.

CAUTION: The cooling fans are hot-pluggable. To maintain proper cooling while the system is on, replace only one fan at a time.

1. Locate the malfunctioning fan.
2. Ensure that the faulty power supply/cooling fan module is properly connected to the enclosure midplane.
3. If the problem is not resolved, install a new power supply/cooling fan module. See "Removing and Installing the Power Supply/Cooling Fan Module" on page 64.

   If the replacement fan does not operate, see "Getting Help" on page 81.

Troubleshooting SAS Physical Disks

CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.

NOTICE: This procedure can destroy data stored on the physical disks. Before you continue, back up all files on the disk.

Problem

- A single physical disk is not seen in MD Storage Manager.

Action

1. Remove the physical disk from the enclosure. See "Removing and Installing Physical Disks" on page 56.
2. Inspect the physical disk and midplane connectors for obvious damage.
3. Re-install the physical disk in its original bay. See "Removing and Installing Physical Disks" on page 56.

   If the problem persists, see "Getting Help" on page 81.

Problem

- Physical disk status LED is flashing amber.

Action

1. Review MD Storage Manager for possible recovery actions.

NOTE: If a physical disk rebuild is under way, allow the rebuild to complete.

2. Remove the physical disk from the enclosure. See "Removing and Installing Physical Disks" on page 56.
3. Inspect the disk and midplane connectors for obvious damage.
4. Re-install the disk in its original bay. See "Removing and Installing Physical Disks" on page 56.

   If the problem persists, see "Getting Help" on page 81.

Problem

- Multiple physical disks are not seen in MD Storage Manager.

Action

1. If you attached an MD1000 expansion enclosure behind a PERC RAID controller, make sure that all cables are attached correctly according to the enclosure mode you selected. For more information on enclosure modes, see the *PowerVault MD3000i Installation Guide*.
2. Verify that the iSCSI port link status LED is solid green for each port that is connected to a cable. If it is not, see "Back-Panel Indicators and Features" on page 18.
3. If you reseated cables, reboot the host server.

   If the problem persists, see "Getting Help" on page 81.

Troubleshooting Enclosure Connections

Problem

- Enclosure is not seen by attached host server.

Action

- Inspect RAID controller module cables for connectivity problems, such as damaged or disconnected cables and poor connections. For detailed cabling instructions, see the *PowerVault MD3000i Installation Guide*.

Hard Controller Failures and Lockdown Conditions

Certain events can cause a RAID controller module to fail and/or shut down. Unrecoverable ECC memory or PCI errors, or critical physical conditions can cause lockdown. If your RAID storage array is configured for redundant access and cache mirroring, the surviving controller can normally recover without data loss or shutdown.

Typical hard controller failures are detailed in the following sections.

Invalid Enclosure

The RAID controller module is supported only in a Dell-supported enclosure. Upon installation in the enclosure, the controller performs a set of validation checks. The enclosure status LED is lit with a steady amber color while the RAID controller module completes these initial tests and the controllers are booted successfully. If the RAID controller module detects a non-Dell supported enclosure, the controller aborts startup. The RAID controller module will not generate any events to alert you in the event of an invalid enclosure, but the enclosure status LED is lit with a flashing amber color to indicate a fault state.

For full details on the LEDs and their interpretation, see "Back-Panel Indicators and Features" on page 18.

ECC Errors

RAID controller firmware can detect ECC errors and can recover from a single-bit ECC error whether the RAID controller module is in a redundant or nonredundant configuration. A storage array with redundant controllers can recover from multi-bit ECC errors as well because the peer RAID controller module can take over, if necessary.

The RAID controller module will failover if it experiences up to 10 single-bit errors, or up to three multi-bit errors.

PCI Errors

The storage enclosure firmware can detect and only recover from PCI errors when the RAID controller modules are configured for redundancy. If a virtual disk uses cache mirroring, it fails over to its peer RAID controller module, which initiates a flush of the dirty cache.

Critical Conditions

The storage array will generate a critical event if the RAID controller module detects a critical condition that could cause immediate failure of the enclosure and/or loss of data. The storage array is in a critical condition if one of the following occurs:

- More than one fan has failed
- Any backplane temperature sensors in the critical range
- Backplane/power supply failure
- Two or more temperature sensors are unreadable
- Failure to detect or unable to communicate with peer port

NOTE: If both RAID controller modules fail simultaneously, the enclosure cannot issue critical or noncritical event alarms for any enclosure component.

When the enclosure is under critical condition, its enclosure status LED blinks amber.

Noncritical Conditions

A noncritical condition is an event or status that will not cause immediate failure, but must be corrected to ensure continued reliability of the storage array. Examples of noncritical events include the following:

- One power supply has failed
- One cooling fan has failed
- One RAID controller module in a redundant configuration has failed
- A battery has failed or has been removed
- A physical disk in a redundant virtual disk has failed

When the enclosure is under noncritical condition, its enclosure status LED blinks amber.

5

Getting Help

Obtaining Assistance

CAUTION: If you need to remove the system cover, first disconnect the power and modem cables from all electrical outlets.

1. Complete the procedures in "Troubleshooting Your Enclosure" on page 71.
2. Review the storage array status in MD Storage Manager and record any information provided.
3. Use Dell's extensive suite of online services available at Dell Support (**support.dell.com**) for help with installation and troubleshooting procedures.

   For more information, see "Online Services" on page 82.
4. If the preceding steps have not resolved the problem, call Dell for technical assistance.

NOTE: Call the support service from a phone near or at the system so that the support staff can assist you with any necessary procedures.

NOTE: Dell's Express Service Code system may not be available in all countries.

When prompted by Dell's automated telephone system, enter your Express Service Code to route the call directly to the proper support personnel. If you do not have an Express Service Code, open the **Dell Accessories** folder, double-click the **Express Service Code** icon, and follow the directions.

For instructions on using the support service, see "Technical Support and Customer Service" on page 82.

NOTE: Some of the following services are not always available in all locations outside the continental U.S. Call your local Dell representative for information on availability.

Technical Support and Customer Service

Dell's support service is available to answer your questions about Dell™ hardware. Our support staff use computer-based diagnostics to provide fast, accurate answers.

To contact Dell's support service, see "Before You Call" on page 84, and then see the contact information for your region or go to **support.dell.com**.

Online Services

You can learn about Dell products and services on the following websites:

www.dell.com/

www.dell.com/ap/ (Asian/Pacific countries only)

www.dell.com/jp (Japan only)

www.euro.dell.com (Europe only)

www.dell.com/la (Latin American countries)

www.dell.ca (Canada only)

You can access Dell Support through the following websites and e-mail addresses:

- Dell Support websites

  support.dell.com

  support.jp.dell.com (Japan only)

  support.euro.dell.com (Europe only)

- Dell Support e-mail addresses

  mobile_support@us.dell.com

  support@us.dell.com

  la-techsupport@dell.com (Latin America and Caribbean countries only)

  apsupport@dell.com (Asian/Pacific countries only)

- Dell Marketing and Sales e-mail addresses

  apmarketing@dell.com (Asian/Pacific countries only)

  sales_canada@dell.com (Canada only)

- Anonymous file transfer protocol (FTP)

  ftp.dell.com/

  Log in as user: `anonymous`, and use your e-mail address as your password.

Automated Order-Status Service

To check on the status of any Dell™ products that you have ordered, you can go to **support.dell.com**, or you can call the automated order-status service. A recording prompts you for the information needed to locate and report on your order. See the contact information for your region.

Dell Enterprise Training

Dell enterprise training is available; see **www.dell.com/training** for more information. This service may not be offered in all locations.

Problems With Your Order

If you have a problem with your order, such as missing parts, wrong parts, or incorrect billing, contact Dell for customer assistance. Have your invoice or packing slip available when you call. See the contact information for your region.

Product Information

If you need information about additional products available from Dell, or if you would like to place an order, visit the Dell website at **www.dell.com**. For the telephone number to call to speak to a sales specialist, see the contact information for your region.

Returning Items for Warranty Repair or Credit

Prepare all items being returned, whether for repair or credit, as follows:

1. Call Dell to obtain a Return Material Authorization Number, and write it clearly and prominently on the outside of the box.

   For the telephone number to call, see the contact information for your region.

2 Include a copy of the invoice and a letter describing the reason for the return.

3 Include a copy of any diagnostic information indicating the tests you have run and any error messages reported by the system diagnostics.

4 Include any accessories that belong with the item(s) being returned (such as power cables, media such as CDs and diskettes, and guides) if the return is for credit.

5 Pack the equipment to be returned in the original (or equivalent) packing materials.

You are responsible for paying shipping expenses. You are also responsible for insuring any product returned, and you assume the risk of loss during shipment to Dell. Collect-on-delivery (C.O.D.) packages are not accepted.

Returns that are missing any of the preceding requirements will be refused at our receiving dock and returned to you.

Before You Call

NOTE: Have your Express Service Code ready when you call. The code helps Dell's automated-support telephone system direct your call more efficiently.

If possible, turn on your system before you call Dell for technical assistance and call from a telephone at or near the system. You may be asked to type some commands at the keyboard, relay detailed information during operations, or try other troubleshooting steps possible only at the computer system itself. Ensure that the system documentation is available.

CAUTION: Before working inside your computer, follow the safety instructions in your *Product Information Guide*.

Contacting Dell

For customers in the United States, call 800-WWW.DELL (800.999.3355).

NOTE: If you do not have an active Internet connection, you can find contact information on your purchase invoice, packing slip, bill, or Dell product catalog.

Dell provides several online and telephone-based support and service options. Availability varies by country and product, and some services may not be available in your area. To contact Dell for sales, technical support, or customer service issues:

1. Visit **support.dell.com**.
2. Verify your country or region in the **Choose A Country/Region** drop-down menu at the bottom of the page.
3. Click **Contact Us** on the left side of the page.
4. Select the appropriate service or support link based on your need.

Choose the method of contacting Dell that is convenient for you.

Glossary

This section defines or identifies technical terms, abbreviations, and acronyms used in your system documents.

A — Ampere(s).

AC — Alternating current.

ACPI — Advanced Configuration and Power Interface. A standard interface for enabling the operating system to direct configuration and power management.

ambient temperature — The temperature of the area or room where the system is located.

ANSI — American National Standards Institute. The primary organization for developing technology standards in the U.S.

application — Software designed to help you perform a specific task or series of tasks. Applications run from the operating system.

ASCII — American Standard Code for Information Interchange.

asset tag — An individual code assigned to a system, usually by an administrator, for security or tracking purposes.

backup — A copy of a program or data file. As a precaution, back up your system's physical disks on a regular basis. Before making a change to the configuration of your system, back up important start-up files from your operating system.

backup battery — A battery that maintains system configuration, date, and time information in a special section of memory when the system is turned off.

beep code — A diagnostic message in the form of a pattern of beeps from your system's speaker. For example, one beep, followed by a second beep, and then a burst of three beeps is beep code 1-1-3.

BIOS — Basic input/output system. Your system's BIOS contains programs stored on a flash memory chip. The BIOS controls the following:

- Communications between the processor and peripheral devices
- Miscellaneous functions, such as system messages

bit — The smallest unit of information interpreted by your system.

blade — A module that contains a processor, memory, and a physical disk. The modules are mounted into a chassis that includes power supplies and fans.

BMC — Baseboard management controller.

boot routine — A program that clears all memory, initializes devices, and loads the operating system when you start your system. Unless the operating system fails to respond, you can reboot (also called *warm boot*) your system by pressing <Ctrl><Alt><Del>. Otherwise, you must restart the system by pressing the reset button or by turning the system off and then back on.

bootable diskette — A diskette that is used to start your system if the system will not boot from the physical disk.

BTU — British thermal unit.

bus — An information pathway between the components of a system. Your system contains an expansion bus that allows the processor to communicate with controllers for the peripheral devices connected to the system. Your system also contains an address bus and a data bus for communications between the processor and RAM.

C — Celsius.

cache — A fast storage area that keeps a copy of data or instructions for quick data retrieval. When a program makes a request to a physical disk for data that is in the cache, the disk-cache utility can retrieve the data from RAM faster than from the physical disk.

CD — Compact disc. CD drives use optical technology to read data from CDs.

cm — Centimeter(s).

cmos — Complementary metal-oxide semiconductor.

component — As they relate to DMI, components include operating systems, computer systems, expansion cards, and peripherals that are compatible with DMI. Each component is made up of groups and attributes that are defined as relevant to that component.

COM*n* — The device names for the serial ports on your system.

control panel — The part of the system that contains indicators and controls, such as the power button and power indicator.

controller — A chip that controls the transfer of data between the processor and memory or between the processor and a peripheral.

conventional memory — The first 640 KB of RAM. Conventional memory is found in all systems. Unless they are specially designed, MS-DOS® programs are limited to running in conventional memory.

coprocessor — A chip that relieves the system's processor of specific processing tasks. A math coprocessor, for example, handles numeric processing.

CPU — Central processing unit. See *processor*.

DC — Direct current.

DDR — Double-data rate. A technology in memory modules that potentially doubles the output.

device driver — A program that allows the operating system or some other program to interface correctly with a peripheral. Some device drivers—such as network drivers—must be loaded from the **config.sys** file or as memory-resident programs (usually, from the **autoexec.bat** file). Others must load when you start the program for which they were designed.

DHCP — Dynamic Host Configuration Protocol. A method of automatically assigning an IP address to a client system.

diagnostics — A comprehensive set of tests for your system.

DIMM — Dual in-line memory module. See also *memory module*.

DIN — *Deutsche Industrie Norm*.

directory — Directories help keep related files organized on a disk in a hierarchical, "inverted tree" structure. Each disk has a "root" directory. Additional directories that branch off the root directory are called *subdirectories*. Subdirectories may contain additional directories branching off them.

DMA — Direct memory access. A DMA channel allows certain types of data transfer between RAM and a device to bypass the processor.

DMI — Desktop Management Interface. DMI enables the management of your system's software and hardware by collecting information about the system's components, such as the operating system, memory, peripherals, expansion cards, and asset tag.

DNS — Domain Name System. A method of translating Internet domain names, such as **www.dell.com**, into IP addresses, such as 143.166.83.200.

DRAM — Dynamic random-access memory. A system's RAM is usually made up entirely of DRAM chips.

DVD — Digital versatile disc.

ECC — Error checking and correction.

EEPROM — Electronically erasable programmable read-only memory.

EMC — Electromagnetic compatibility.

EMI — Electromagnetic interference.

EMM — Enclosure Management Module.

ERA — Embedded remote access. ERA allows you to perform remote, or "out-of-band," server management on your network server using a remote access controller.

ESD — Electrostatic discharge.

ESM — Embedded server management.

expansion bus — Your system contains an expansion bus that allows the processor to communicate with controllers for peripherals, such as NICs.

expansion card — An add-in card, such as a NIC or SCSI adapter, that plugs into an expansion-card connector on the system board. An expansion card adds some specialized function to the system by providing an interface between the expansion bus and a peripheral.

expansion-card connector — A connector on the system board or riser board for plugging in an expansion card.

F — Fahrenheit.

FAT — File allocation table. The file system structure used by MS-DOS to organize and keep track of file storage. The Microsoft® Windows® operating systems can optionally use a FAT file system structure.

flash memory — A type of EEPROM chip that can be reprogrammed from a utility on diskette while still installed in a system; most EEPROM chips can only be rewritten with special programming equipment.

format — To prepare a physical disk or diskette for storing files. An unconditional format deletes all data stored on the disk.

FSB — Front-side bus. The FSB is the data path and physical interface between the processor and the main memory (RAM).

ft — Feet.

FTP — File transfer protocol.

g — Gram(s).

G — Gravities.

Gb — Gigabit(s); 1024 megabits or 1,073,741,824 bits.

GB — Gigabyte(s); 1024 megabytes or 1,073,741,824 bytes. However, when referring to physical disk capacity, the term is usually rounded to 1,000,000,000 bytes.

graphics mode — A video mode that can be defined as *x* horizontal by *y* vertical pixels by *z* colors.

group — As it relates to DMI, a group is a data structure that defines common information, or attributes, about a manageable component.

guarding — A type of data redundancy in which a set of physical disks stores data and an additional disks stores parity data. See also *mirroring*, *striping*, and *RAID*.

h — Hexadecimal. A base-16 numbering system, often used in programming to identify addresses in the system's RAM and I/O memory addresses for devices. In text, hexadecimal numbers are often followed by *h*.

headless system — A system or device that functions without having a keyboard, mouse, or monitor attached. Normally, headless systems are managed over a network using an Internet browser.

host adapter — A host adapter implements communication between the system's bus and the controller for a peripheral device. (Disk controller subsystems include integrated host adapter circuitry.) To add a SCSI expansion bus to your system, you must install or connect the appropriate host adapter.

hot-pluggable — The ability to remove a system component or attached device without powering down the system. While a component may be "hot-pluggable," you should never remove a component or device while data traffic is occurring that involves the component. For more information, see the documentation for your specific component or device.

Hz — Hertz.

I/O — Input/output. A keyboard is an input device, and a monitor is an output device. In general, I/O activity can be differentiated from computational activity.

ID — Identification.

IDE — Integrated drive electronics. A standard interface between the system board and storage devices.

integrated mirroring — Provides simultaneous physical mirroring of two drives. Integrated mirroring functionality is provided by the system's hardware. See also *mirroring*.

internal processor cache — An instruction and data cache built into the processor.

IP — Internet Protocol.

IPX — Internet package exchange.

IRQ — Interrupt request. A signal that data is about to be sent to or received by a peripheral device travels by an IRQ line to the processor. Each peripheral connection must be assigned an IRQ number. Two devices can share the same IRQ assignment, but you cannot operate both devices simultaneously.

iSCSI — Internet SCSI (Small Computer System Interface), a new Internet Protocol (IP)-based storage networking standard for linking data storage facilities, developed by the Internet Engineering Task Force (IETF).

jumper — Small blocks on a circuit board with two or more pins emerging from them. Plastic plugs containing a wire fit down over the pins. The wire connects the pins and creates a circuit, providing a simple and reversible method of changing the circuitry in a board.

K — Kilo-; 1000.

Kb — Kilobit(s); 1024 bits.

KB — Kilobyte(s); 1024 bytes.

Kbps — Kilobit(s) per second.

KBps — Kilobyte(s) per second.

key combination — A command requiring you to press multiple keys at the same time (for example, <Ctrl><Alt><Del>).

kg — Kilogram(s); 1000 grams.

kHz — Kilohertz.

KMM — Keyboard/monitor/mouse.

KVM — Keyboard/video/mouse. KVM refers to a switch that allows selection of the system from which the video
is displayed and for which the keyboard and mouse are used.

LAN — Local area network. A LAN is usually confined to the same building or a few nearby buildings, with all equipment linked by wiring dedicated specifically to the LAN.

lb — Pound(s).

LCD — Liquid crystal display.

LED — Light-emitting diode. An electronic device that lights up when a current is passed through it.

Linux — An operating system similar to UNIX® systems that runs on a variety of hardware systems. Linux is open source software, which is freely available; however, the full distribution of Linux along with technical support and training are available for a fee from vendors such as Red Hat® Software.

local bus — On a system with local-bus expansion capability, certain peripheral devices (such as the video adapter circuitry) can be designed to run much faster than they would with a traditional expansion bus. See also *bus*.

LVD — Low voltage differential.

m — Meter(s).

mA — Milliampere(s).

MAC address — Media Access Control address. Your system's unique hardware number on a network.

mAh — Milliampere-hour(s).

Mb — Megabit(s); 1,048,576 bits.

MB — Megabyte(s); 1,048,576 bytes. However, when referring to physical disk capacity, the term is often rounded to mean 1,000,000 bytes.

Mbps — Megabits per second.

MBps — Megabytes per second.

MBR — Master boot record.

memory address — A specific location, usually expressed as a hexadecimal number, in the system's RAM.

memory module — A small circuit board containing DRAM chips that connects to the system board.

memory — An area in your system that stores basic system data. A system can contain several different forms of memory, such as integrated memory (ROM and RAM) and add-in memory modules (DIMMs).

MHz — Megahertz.

mirroring — A type of data redundancy in which a set of physical disks stores data and one or more sets of additional disks stores duplicate copies of the data. Mirroring functionality is provided by software. See also *guarding*, *integrated mirroring*, *striping*, and *RAID*.

mm — Millimeter(s).

ms — Millisecond(s).

MS-DOS® — Microsoft Disk Operating System.

NAS — Network Attached Storage. NAS is one of the concepts used for implementing shared storage on a network. NAS systems have their own operating systems, integrated hardware, and software that are optimized to serve specific storage needs.

NIC — Network interface controller. A device that is installed or integrated in a system to allow connection to a network.

NMI — Nonmaskable interrupt. A device sends an NMI to signal the processor about hardware errors.

ns — Nanosecond(s).

NTFS — The NT File System option in the Windows 2003 operating system.

NVRAM — Nonvolatile random-access memory. Memory that does not lose its contents when you turn off your system. NVRAM is used for maintaining the date, time, and system configuration information.

parity — Redundant information that is associated with a block of data.

partition — You can divide a physical disk into multiple physical sections called *partitions* with the **fdisk** command. Each partition can contain multiple logical disks. You must format each logical disk with the **format** command.

PCI — Peripheral Component Interconnect. A standard for local-bus implementation.

PDU — Power distribution unit. A power source with multiple power outlets that provides electrical power to servers and storage systems in a rack.

peripheral — An internal or external device, such as a diskette drive or keyboard, connected to a system.

PGA — Pin grid array. A type of processor socket that allows you to remove the processor chip.

physical disk — A hard drive installed in the RAID enclosure.

pixel — A single point on a video display. Pixels are arranged in rows and columns to create an image. A video resolution, such as 640 x 480, is expressed as the number of pixels across by the number of pixels up and down.

POST — Power-on self-test. Before the operating system loads when you turn on your system, the POST tests various system components such as RAM and physical disks.

processor — The primary computational chip inside the system that controls the interpretation and execution of arithmetic and logic functions. Software written for one processor must usually be revised to run on another processor. *CPU* is a synonym for processor.

protected mode — An operating mode that allows operating systems to implement:

- A memory address space of 16 MB to 4 GB
- Multitasking
- Virtual memory, a method for increasing addressable memory by using the physical disk

The Windows 2003 and Linux 32-bit operating systems run in protected mode. MS-DOS cannot run in protected mode.

PS/2 — Personal System/2.

PXE — Preboot eXecution Environment. A way of booting a system via a LAN (without a physical disk or bootable diskette).

RAC — Remote access controller.

RAID — Redundant array of independent disks. A method of providing data redundancy. Some common implementations of RAID include RAID 0, RAID 1, RAID 5, RAID 10, and RAID 50. See also *guarding*, *mirroring*, and *striping*.

RAID enclosure — A storage enclosure supporting RAID via a modular controller unit.

RAID array — Collection of storage disks managed under a RAID solution. The RAID array includes any disks attached to the RAID controller, including those contained in a supported expansion enclosure.

RAM — Random-access memory. The system's primary temporary storage area for program instructions and data. Any information stored in RAM is lost when you turn off your system.

RAS — Remote Access Service. This service allows users running the Windows operating system to remotely access a network from their system using a modem.

readme file — A text file, usually shipped with software or hardware, that contains information supplementing or updating the product's documentation.

read-only file — A read-only file is one that you are prohibited from editing or deleting.

ROM — Read-only memory. Your system contains some programs essential to its operation in ROM code. A ROM chip retains its contents even after you turn off your system. Examples of code in ROM include the program that initiates your system's boot routine and the POST.

ROMB — RAID on motherboard.

rpm — Revolutions per minute.

RTC — Real-time clock.

SAN — Storage area network. A configuration of computer and storage systems that incorporate dedicated Fibre Channel connectivity between the computer systems and storage. A SAN bypasses traditional network bottlenecks and supports direct high-speed data transfer between the servers and storage devices. SAN storage may consist of both hard-disk drive and tape storage devices that are connected through switches and bridges to multiple servers.

SCSI — Small computer system interface. An I/O bus interface with faster data transmission rates than standard ports.

SDRAM — Synchronous dynamic random-access memory.

sec — Second(s).

serial port — An I/O port used most often to connect a modem to your system. You can usually identify a serial port on your system by its 9-pin connector.

service tag — A bar code label on the system used to identify it when you call Dell for technical support.

simple disk volume — The volume of free space on a single dynamic, physical disk.

SMART — Self-Monitoring Analysis and Reporting Technology. Allows physical disks to report errors and failures to the system BIOS and then display an error message on the screen.

SMP — Symmetric multiprocessing. Used to describe a system that has two or more processors connected via a high-bandwidth link and managed by an operating system, where each processor has equal access to I/O devices.

SNMP — Simple Network Management Protocol. A standard interface that allows a network manager to remotely monitor and manage workstations.

spanning — Spanning, or concatenating, disk volumes combines unallocated space from multiple disks into one logical volume, allowing more efficient use of all the space and all physical disk drive letters on a multiple-disk system.

striping — Disk striping writes data across three or more disks in an array, but only uses a portion of the space on each disk. The amount of space used by a "stripe" is the same on each disk used. A virtual disk may use several stripes on the same set of disks in an array. See also *guarding*, *mirroring*, and *RAID*.

SVGA — Super video graphics array. VGA and SVGA are video standards for video adapters with greater resolution and color display capabilities than previous standards.

system board — As the main circuit board, the system board usually contains most of your system's integral components, such as the processor, RAM, controllers for peripherals, and various ROM chips.

system configuration information — Data stored in memory that tells a system what hardware is installed and how the system should be configured for operation.

system diskette — See *bootable diskette*.

system memory — See *RAM*.

System Setup program — A BIOS-based program that allows you to configure your system's hardware and customize the system's operation by setting features such as password protection. Because the System Setup program is stored in NVRAM, any settings remain in effect until you change them again.

system.ini file — A start-up file for the Windows operating system. When you start Windows, it consults the **system.ini** file to determine a variety of options for the Windows operating environment. Among other things, the **system.ini** file records which video, mouse, and keyboard drivers are installed for Windows.

TCP/IP — Transmission Control Protocol/Internet Protocol.

termination — Some devices (such as the last device at each end of a SCSI cable) must be terminated to prevent reflections and spurious signals in the cable. When such devices are connected in a series, you may need to enable or disable the termination on these devices by changing jumper or switch settings on the devices or by changing settings in the configuration software for the devices.

uplink port — A port on a network hub or switch used to connect to other hubs or switches without requiring a crossover cable.

UPS — Uninterruptible power supply. A battery-powered unit that automatically supplies power to your system in the event of an electrical failure.

USB — Universal Serial Bus. A USB connector provides a single connection point for multiple USB-compliant devices, such as mice and keyboards. USB devices can be connected and disconnected while the system is running.

utility — A program used to manage system resources—memory, disk drives, or printers, for example.

UTP — Unshielded twisted pair. A type of wiring used to connect systems in a business or home to a telephone line.

V — Volt(s).

VAC — Volt(s) alternating current.

VDC — Volt(s) direct current.

VGA — Video graphics array. VGA and SVGA are video standards for video adapters with greater resolution and color display capabilities than previous standards.

video adapter — The logical circuitry that provides (in combination with the monitor) your system's video capabilities. A video adapter may be integrated into the system board or may be an expansion card that plugs into an expansion slot.

video driver — A program that allows graphics-mode application programs and operating systems to display at a chosen resolution with the desired number of colors. Video drivers may need to match the video adapter installed in the system.

video memory — Most VGA and SVGA video adapters include memory chips in addition to your system's RAM. The amount of video memory installed primarily influences the number of colors that a program can display (with the appropriate video drivers and monitor capabilities).

video resolution — Video resolution (800 x 600, for example) is expressed as the number of pixels across by the number of pixels up and down. To display a program at a specific graphics resolution, you must install the appropriate video drivers and your monitor must support the resolution.

W — Watt(s).

WH — Watt-hour(s).

win.ini file — A start-up file for the Windows operating system. When you start Windows, it consults the **win.ini** file to determine a variety of options for the Windows operating environment. The **win.ini** file also usually includes sections that contain optional settings for Windows application programs that are installed on the physical disk.

Windows Powered — A Windows operating system designed for use on NAS systems. For NAS systems, the Windows Powered operating system is dedicated to file service for network clients.

Windows Server 2003 — A set of Microsoft software technologies that enable software integration through the use of XML Web services. XML Web services are small reusable applications written in XML that allow data to be communicated between otherwise unconnected sources.

XML — Extensible Markup Language. XML is a way to create common information formats and to share both the format and the data on the World Wide Web, intranets, and elsewhere.

ZIF — Zero insertion force.

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